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NOTE: This **DRAFT** dated September 28, 2001 prepared by AND-360

has **not** been approved and is subject to modification.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

NEXT GENERATION AIR/GROUND COMMUNICATIONS (NEXCOM) SYSTEM REQUIREMENTS DOCUMENT (SRD)

INTERIM DRAFT
Modified September 28, 2001
Version 1.0

The Next Generation Air/Ground Communications System
Integrated Product Team, AND-360

DISTRIBUTION STATEMENT

1 INTRODUCTION

This is the System Requirements Document (SRD) for the Next Generation Air/Ground Communications (NEXCOM) System.

1.1 Background

The Mission Need Statement (MNS 137) and the subsequent NEXCOM Investment Analysis Report describe shortfalls in the spectrum capacity of the current Air/Ground (A/G) communications system. Demand for new A/G communication voice frequency assignments, especially for already congested terminal and surrounding airspace, and for frequencies to support a variety of new A/G communications services in the limited very high frequency (VHF) band is expected to grow four percent annually. This level of growth cannot be accommodated by the current analog system. Other needs called out in the MNS include a reduction in logistical costs for maintaining radios, introduction of new data link capability, a reduction in radio frequency interference (RFI), and improved security against threats such as “phantom controllers.”

In response to these needs, the NEXCOM Requirements Document (RD) identified a segmented program for upgrade and replacement of the present air traffic control (ATC) A/G communications string. The RD also identified a number of operational and technical constraints, which must be accommodated while satisfying these requirements. Specifically, a fundamental requirement of NEXCOM Segment 1 (NS1) is to provide additional voice channels with no disruption of the present voice service. Furthermore, NEXCOM is to achieve this increased capacity with minimum disruption of the present VHF A/G communications physical system configuration. Finally, NEXCOM seeks a seamless evolution from the present analog double sideband-amplitude modulation (DSB-AM) A/G system to the new digital communications functional capability.

The Joint Resources Council (JRC) approved Segment 1 of the NEXCOM System in May 1998. NEXCOM System would have introduced VHF Digital Link (VDL) Mode 3 digital voice capability to the en route environment.

In 1999, the NEXCOM acquisition strategy was revised in order to mitigate perceived risks associated with the 1998 JRC approved strategy. The revised strategy delays the introduction of digital voice as first planned to meet ATC requirements, but incorporates risk mitigation and budget affordability. The new strategy focuses on ensuring that NEXCOM is fully integrated with the NAS, that the ground and airborne systems are developed and deployed in a coordinated manner, and that the initial NEXCOM System follow-on support services progress in an incremental manner. This revised acquisition strategy was approved by the JRC in May 2000.

The revised strategy includes three segments:

- Segment One includes:

    a) Procurement of multi-mode digital radios in FY01, which is consistent with the 1998 NEXCOM JRC approved Acquisition Strategy Paper (ASP)

    b) Building user consensus, buy-in and commitment through working with industry and with both standards and rulemaking bodies to encourage timely development and equipage of VDL Mode 3 avionics.

c) Developing and evaluating the NEXCOM integrated voice and data system to mitigate risk associated with the separate voice and data implementation plan of the original strategy

d) Continuing to reduce spectrum congestion, where possible, via workarounds

e) Producing and deploying digital voice for high and super high en route sectors

- Segment Two adds data capability to the high and super high en-route sectors.

- Segment Three extends NEXCOM digital voice and data to other operational environments.

1.2 Purpose

This SRD serves as the focal point for all system requirements affecting the development of the hardware and software necessary to implement the VDL Mode 3 system with the capability for integrated voice and data. The NEXCOM System also introduces new requirements on external equipment that interfaces with it. It represents the FAA requirements and system integration through a detailed functional and performance allocation to relevant NEXCOM Subsystems. The SRD provides requirements traceability from the RD and other relevant National Airspace System (NAS) implementation policies, orders, and standards to each detailed subsystem specification.

1.3 Scope

This document describes the NEXCOM System requirements. It establishes:

- System boundaries and the system architecture and interfaces within those bounds

- System technical characteristics including functional and performance requirements

- Operating environments

This document transcends all NEXCOM segments and includes data requirements. The ground network interface (GNI) will eventually perform subnetwork management in the Aeronautical Telecommunications Network (ATN) environment.

This SRD recognizes the avionics element as integral to system operation. However, avionics requirements are discussed only as they affect the ground system design. The scope of the document is focused on the NEXCOM ground system.

Figure 1-1 identifies the RD for NEXCOM as the source of the top-level program requirements. In addition to the operational requirements, the RD identifies and references other high level documents and/or activities that must be considered when deriving the major technical constraints placed on the system design.

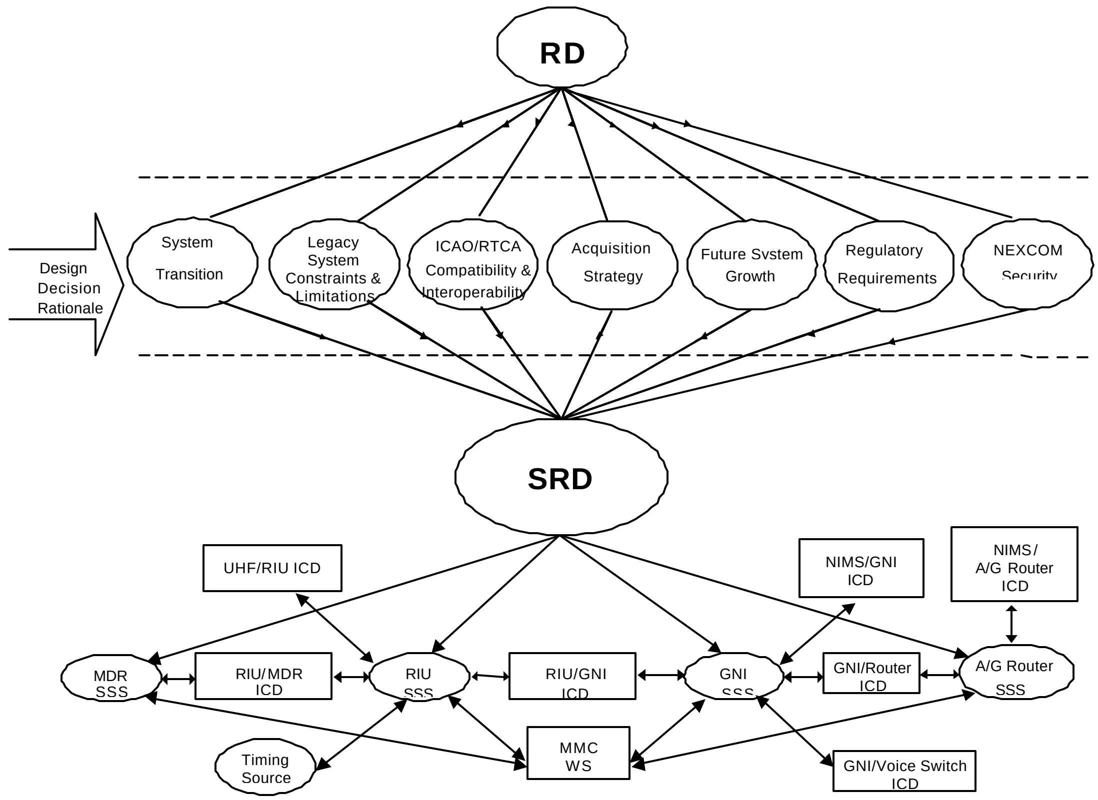


Figure 1-1 SRD Document Development Process

This SRD responds to the RD and defines each NEXCOM Subsystem and its boundaries as a result of technical consideration of the major categories noted in the Design Decision Rationale of the diagram. The SRD is the parent document for each subordinate NEXCOM Subsystem Specifications (SSS) for the Multimode Digital Radio (MDR), the Radio Interface Unit (RIU), the Ground Network Interface (GNI), and the Air/Ground Router. It also influences Interface Control Documents (ICDs) between NEXCOM Subsystems and ICDs for interfacing with other linked systems.

Besides the requirements of the RD, the major areas of architectural influence identified in the diagram are discussed briefly below:

- System Transition – The NEXCOM System must operate within the allocated A/G VHF communications spectrum and co-exist with the present analog DSB-AM system. Simulcast of analog and digital communications on separate frequencies within a sector is not envisioned as a nationwide system option; hence, proposed system transition plans require that all users operating in a sector be equipped appropriately. Furthermore, the first implemented segment must leverage the existing telecommunications infrastructure, as applicable, to meet its digital voice requirements. An efficient transition will first allow the benefits of spectrally efficient A/G communications that provide additional new voice channels and then include data with new voice and data communication and control features. A smooth transition plan from the current VHF spectrum usage and an integrated plan for supporting digital telecommunications and attendant interfaces will be required. Such plans require that NEXCOM MDRs be capable of being installed and operated in analog mode until such time as a full cutover of the sector to VDL Mode

3 operation can be made. At cutover, to operate in a digital sector, aircraft must be equipped with VDL Mode 3 avionics.

- Legacy System – The NEXCOM System must interface with existing equipment and operate within existing Remote Communications Facilities (RCFs). Also, the equipment must use and be compatible with the current support infrastructure such as power grids, heating, ventilation and air conditioning (HVAC). Additionally, the NEXCOM equipment must satisfy the unique requirements of existing equipment. This includes services performed by the Radio Control Equipment (RCE), which will eventually be removed and replaced by NEXCOM equipment.

- International Civil Aviation Organization (ICAO) compatibility – The NEXCOM System must provide interoperable communications on an international basis. Operational modes within the NEXCOM System must be compliant with ICAO Standards and Recommended Practices (SARPs), be consistent with RTCA Minimum Aviation System Performance Standards (MASPS), and be compatible with RTCA Minimum Operational Performance Standards (MOPS).

- Acquisition Strategy – The NEXCOM acquisition is a Non-Developmental Item (NDI) procurement for the MDR and a developmental contract for other components of the NEXCOM System. As part of the NAS sustainment activity, the NEXCOM System must provide new radio capability, in addition to legacy capability, through form and functionally compatible equipment for replacement of the currently fielded radios. The NEXCOM System will be procured in segment steps, which deliver separate benefits in a building block strategy.

- Future System Growth – The NEXCOM System must be capable of evolving to meet anticipated voice and data demand and provide for an integrated digital voice and data link functionality. To do this, existing telecommunications may be upgraded to support these new services.

- Regulatory Requirements – The NEXCOM System must meet all regulatory requirements that are determined to be appropriate. This determination will be made based on knowledge of regulatory requirements and the evaluation of the SRD as it applies to those requirements. It is anticipated that the NEXCOM Subsystems will be determined to be level C equipment under the safety assessment definitions provided by RTCA DO-178B guidance. The application of this guidance is still under review.

- NEXCOM Security – The NEXCOM system must meet Security Requirements outlined in FAA Order 1370.82. The System must meet certification and authorization requirements in accordance with FAA Guidelines and introduce no vulnerabilities to the NAS or other systems it interfaces to.

1.4 Document Organization

Section 1 states the purpose and scope of this specification, its relationship to other program source requirements documents, and the driving influences that must be considered in satisfying those requirements. It also defines terminology that provides the basis for consistent reference in developing system level requirements.

Section 2 defines the applicable reference documents cited in this specification.

Section 3 specifies the NEXCOM System functional, performance, and other top-level requirements. This section is formatted so that functional requirements are identified prior to the corresponding performance requirements. However, these requirements are in differing section (functional requirements identified in section 3.2 correspond to performance requirements in 3.3 and have similar numbering).

Section 4 defines the verification process for the NEXCOM program.

Section 5 provides applicable notes for this SRD.

Appendix A provides general NAS A/G site configuration information about the current A/G communication systems.

Appendix B identifies NEXCOM System architecture for the functional allocation presented in Section 3.

Appendix C RESERVED.

Appendix D provides traceability matrices that map RD and other source requirements to SRD requirements.

Appendix E provides the Reliability, Maintainability, and Availability (RMA) allocation of the proposed system architecture identified in Section 3.

Appendix F provides a detailed budget for end-to-end audio delay allocations for the NEXCOM System.

1.5 Definitions

A/G Communications System - All equipment and functionality in the ground path from the controller to the antenna, including redundancy, that provide radio communication services.

Air/Ground Router - A router in NEXCOM System that is based on ICAO defined routing protocols for Aeronautical Telecommunications Network (ATN). It is the access point for the NEXCOM System to the NAS ATN network. This Air/Ground Router supports a dynamic routing process that allows the route information possessed by each router to be updated as a result of the movement of the aircraft.

Authentication – identification and authorization within the NAS is the process by which automated mechanisms in the NAS verify the claimed identity of a user who is attempting to access the system. A user is authenticated and identified only in the context of an existing session whereby the user is actually interfacing with the system. A user is not authenticated until after the system accepts whatever evidence is presented by the user seeking access for that particular session. That evidence could range from nothing, to a simple password, to some challenge/response dialog, to some physically possessed token with on-board cryptography based identification mechanism.

Beacon - Beacon is a function of the VDL Mode 3 ground radio uplink Management (M) burst that conveys critical system configuration information and the system timing reference to the aircraft radios for net initialization and continued net operation.

DLS Frame - VDL Mode 3 datalink service entity protocol units.

Downlink - Communication from a mobile user to a ground user.

En route Communications (ECOM) Service - Radio communications between the ARTCC and in-flight aircraft.

Ground Network Interface (GNI) - ATC control site equipment that interfaces with the voice switch and the Air/Ground Router to exchange voice and data between air traffic controllers and aircraft in User Groups through RIUs and MDRs at local and remote A/G radio sites.

Harmful Interference - Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with the Regulations.

Malicious Code and Data – Hardware, software, or firmware that is intentionally included in a system for an unauthorized purpose; e.g., a Trojan horse.

Momentary Interruption - Power loss/degradation that does not affect the operation of the system.

Multimode Digital Radio (MDR) - The NEXCOM ground site A/G VHF radio consisting of a separate VHF transmitter unit and a separate VHF receiver unit configured to operate in one of three selectable modes, 25 kHz DSB-AM (existing analog voice only), 8.33 kHz DSB-AM (analog voice only), and VDL Mode 3 (digital voice and data on the same frequency in separate time slots).

NEXCOM System - All control site and remote site equipment in the voice/data ground path from the output of the voice switch (or in the future possibly the output of the controller console automation system) and the NAS ATN Ground/Ground Router to the antenna port of the radio (exclusive of telecommunication or other interfacility transmission media).

NEXCOM Subsystem - An element in the NEXCOM System that provides new functional capability for the NAS.

PCM Voice Message - The message communicated between the RIU and MDR to pass a portion of uncompressed, digitized audio information encoded using pulse code modulation.

Power Failure - Power loss/degradation that does effect the operation of the system and causes the system/subsystem to lose any volatile state information.

Radio Control Equipment (RCE) - Existing analog radio control equipment which will be replaced by functionality in GNIs at control sites and in RIUs at A/G radio sites.

Radio Interface Unit (RIU) - A ground radio site unit that interfaces with and controls operation of specific MDR units and specific legacy UHF DSB-AM A/G radios, contains vocoders to convert voice signals between analog and digital, interfaces with an external time source to provide NEXCOM System timing to MDRs, and interfaces with a GNI at the control site usually through a telecommunications link.

String (also referred to as thread) - A circuit (closed path), providing communication for a User Group through the NEXCOM System.

Strong Authentication – Authentication with two or more factors used in authentication process. Three possible choices are something you know (e.g., password), something you have (e.g., token), or something you are (e.g., fingerprint).

Sustainment - A NEXCOM 25 kHz DSB-AM mode that retains the existing A/G Communication System architecture, while incorporating NEXCOM VHF MDR transmitters and receivers in control and remote A/G VHF radio sites without modifying existing racks, power, or other supporting infrastructure.

Talk Group - A group of ground and/or aircraft stations, which share direct voice connectivity. Talk Group is a subset of User Group. In this SRD UHF stations and the associated VHF stations are treated as separate Talk Groups with the ground station common to both the UHF and VHF Talk Groups. For Dual Control operations the UHF and the associated VHF Talk Groups are commonly called paired Talk Groups.

Thread (also referred to as string) - A circuit (closed path), providing communication for a User Group through the NEXCOM System.

Uplink - Communication from a ground user to a mobile user.

User Group - A group of ground and/or aircraft stations, which share direct voice and/or data connectivity. In this SRD the UHF stations and the associated VHF stations are treated as separate User Groups.

Voice Burst Message - The message communicated between the GNI and RIU, or RIU and MDR to pass the compressed, digitized audio information associated with one to six vocoder frame(s).

1.6 Programmatic Assumptions

The NEXCOM architecture is based on the following assumptions:

- The RCE and BUEC improvement programs will be completed prior to the fielding of the NEXCOM System.
- The FAA ground infrastructure is required to support only 25 kHz DSB-AM and VDL Mode 3 operation throughout the transition from DSB-AM to VDL Mode 3. However, for risk mitigation purposes, 8.33 kHz DSB-AM is included as an MDR radio function.
- VHF radio sustainment is part of NEXCOM. NEXCOM will use the MDR 25 kHz DSB-AM capability for current infrastructure sustainment.
- Ultra High Frequency (UHF) A/G communications will remain analog and will continue to require support from NEXCOM. UHF radio replenishment is not part of the NEXCOM program.
- NEXCOM will continue to support 121.5 MHz emergency communication using DSB-AM modulation.
- No new radio sites are required for the NEXCOM program.
- VDL Mode 2 is not part of the NEXCOM System. It is part of the Aeronautical Data Link (ADL) System and is interfaced through the NAS A/G Routers to the service provider.
- The NEXCOM System will be classified a critical service as defined in NAS SR-1000, as stated in the NEXCOM RD Section 3.2.1.1.

2 APPLICABLE DOCUMENTS

The following documents form a part of this SRD to the extent specified herein. Secondary references, or those documents referenced by documents contained in this section, also form a part of this SRD to the extent specified by applicable sections of the documents referenced directly in this section.

2.1 Government Documents

2.1.1 FAA Specifications

Doc No.	Document Title	Version / Date[1]	Sections[2]
FAA-C-1217F	*Electrical Work, Interior*	February 26, 1996	
FAA-E-2885	*Down Scoped Radio Control Equipment (DSRCE)*	December 15, 1993	
FAA-E-2911	*System Level Specification, NAS Infrastructure Management System (NIMS) Managed Subsystems*		
FAA-E-2938	*Subsystem Specification, Multimode Digital Radio (MDR)*	September 20, 2000	
FAA-E-2944	*Multimode Digital Radio (MDR) Maintenance Data Terminal (MDT) Maintenance Application Software Requirements Specification*	August 8, 2000	
FAA-G-2100G	*Electrical Equipment, General Requirements,*	September 28, 1999	
FAA-P-2883	*Purchase Description, VHF/UHF Air/Ground Communications Receivers*	April 14, 1994	
FAA-P-2884	*Purchase Description, VHF/UHF Air/Ground Communications Transmitters*	April 14, 1994	
NAS-SR-1000	*NAS System Requirements Specification*	November 27, 1991	
NAS-SS-1000	*NAS System Specification, Volume I*	December, 1986	3.2.x

2.1.2 FAA Standards

Doc No.	Document Title	Version / Date	Sections
FAA-STD-019C	*Lightning Protection, Grounding, Bonding, and Shielding for Facilities*	June 1, 1999	
FAA-STD-020B	*Transient Protection, Grounding, Bonding, and Shielding Requirements for Equipment*	May 11, 1992	
FAA-STD-032B	*Design Standards for National Airspace System Physical Facilities*	April 29, 1986 and August 1, 1996	

[1] Dates and versions are the latest that could be found.
[2] Sections referenced are used at a minimum. Others may apply.

2.1.3 FAA Orders

Doc No.	Document Title	Version / Date	Sections
FAA Order 1600.6	*FAA Physical Security Management Program*		
FAA Order 1600.68	*Security Policy Statement and Roles and Responsibilities*	March 5, 1999 (draft)	
FAA Order 1370.82[3]	*Information Systems Security Program*	June 9, 2000	
FAA Order 1800.58A	*NAS Integrated Logistics Policy*	August 19, 1993	
FAA Order 3900.19B	*Occupational Safety and Health Program*	April 29, 1999	Chap 1: par 7e, 7l
FAA Order 6000.30C[4]	*National Airspace System Maintenance Policy*		Sec 11 (a and e)
FAA Order 6000.36	*Communications Diversity*	March 20, 1990	
FAA Order 6030.20E	*Electrical Power Policy*	October 15, 1989	
FAA Order 6040.15C	*Analysis of Facility/Service Performance*	January 2, 1993	par 702
FAA Order 6050.32	*Spectrum Management Regulations and Procedures Manual*	May 1, 1998	
FAA Order 6580.3A	*Remote Communications Facilities Installation Standards Handbook*		
FAA Order 6630.4A	*En route Communications Installation Standards Handbook*	July 9, 1999 Rev A and May 16, 1983	
FAA Order 6950.2D	*Electrical Power Policy Implementation NAS Facilities*	October 1, 1998	
FAA Order 6950.19A	*Practices and Procedures for Lightning Protection Grounding, Bonding, and Shielding Implementation*	July 1, 1996	
FAA Order 6950.20	*Fundamental Considerations of Lightning Protection Grounding, Bonding, and Shielding*	August 20, 1985	
FAA Order 6950.25A	*Use of Electrical Power Conditioning Devices at FAA Facilities*	July 2, 1998	

2.1.4 Other FAA Documents

Doc No.	Document Title	Version / Date	Sections
NEXCOM RD	*Requirements Document for Next Generation Air/Ground Communications System (NEXCOM), Segment 1*	May 4, 1998	

[3] Supercedes FAA Order 1600.66 and 1600.54B.
[4] Supercedes FAA Order 6000.30B *Policy for Maintenance of the NAS through the Year 2000.*

CPDLC RD	*Requirements Document for the Controller-Pilot Data Link Communications*	
NAS-IC-41033502	*Interface Control Document, Multimode Digital Radio/Radio Interface Unit*	September 26, 2000
NAS-IC-42024000	*VSCS to the existing Radio Control Equipment Interface Control Document*	October 10, 1997
NAS-IR-41024201	*Interface Requirements Document Voice Switching and Control System to Radio Control Equipment*	July 30, 1987
NAS-IR-51070000	*NAS Infrastructure Management System Manager/Managed Subsystem Interface Requirements Document*	May 28, 1997
MNS 137	*Next Generation A/G Communications System*	March 6, 1995
DOT/FAA/RD-95/3.1	*Human Factors for the Design and Evaluation of Air Traffic Control Systems*	1995
	FAA System Safety Handbook	August 2000 (draft)
DOT/FAA/CT-96/1	*FAA Human Factors Design Guide*	January 15, 1996
DOT SS-98-01	*DOT Policy for Seismic Safety in Existing Facilities*	January 1998
NAS-IR-61004102	*Area Control Facility/ Radio Control Equipment (ACF/RCE)*	July 18, 1989
NAS-IR-41024207A	*Terminal Voice Switch (TVS)/Radio Control Equipment (RCE)*	November 3, 1994
NAS-IC-51070000-1 Rev. A	*NAS Infrastructure Management System Manager/Managed Subsystem Using the Simple Network Management Protocol Version 1 (SNMPv1) Interface Control Document*	May 1, 1998
NAS-IC-42014000	*VSCS to the Existing Radio Control Equipment ICD for the Voice Switching and Control System (VSCS)*	October 10, 1997
NAS-IC-41024201	*VSCS to Radio Control Equipment ICD for the Voice Switching and Control System, (VSCS)*	October 10, 1997
NAS-IC-64024201	*VSCS to Backup Emergency Communications ICD for the Voice Switching and Control System, (VSCS)*	August 8, 1997

2.1.5 Other Government Documents

Doc No.	Document Title	Version / Date	Sections
EPAct	*Energy Policy Act of 1992*	October 24, 1992	Title I, Subtitle F, Sects. 152 and 161
Executive Order 12088	*Federal Compliance with Pollution Control Standards, as amended by EO 12580*	October 13, 1978	
Executive	*Greening the Government through Waste*	September 14,	

Order 13101	*Prevention, Recycling, and Federal Acquisition*	1998	
Executive Order 13123[5]	*Greening the Government through Efficient Energy Management*	June 3, 1999	
Executive Order 12873	*Federal Acquisition, Recycling, and Waste Prevention*	October 20, 1993	
Executive Order 12699	*DOT Implementation of Energy Order 12699*		
Executive Order 12902	*Energy Efficiency and Conservation at Federal Facilities*		
FEMA-74	*Reducing the Risk of Non-Structural Earthquake Damage, Third Edition*	September 1994	
40 CFR var. Parts	*Environmental Protection Agency Regulations*	July 1, 2000	Part 261
49 CFR 41	*Seismic Safety*	July 14, 1993	
29 CFR, 1910	*Occupational Safety And Health Standards*	July 1, 1999	
29 CFR, 1926	*Safety and Health Regulations for Construction*	Various	

2.2 Non-Government Documents

2.2.1 ICAO Standards

Doc No.	Document Title	Version / Date	Sections
ICAO Annex 10	*International Standards and Recommended Practices (SARPs)* *- Volume II (ATN SARPs)*		
ICAO Doc 9705	*Manual on the Technical Provisions for the Aeronautical Telecommunications Network (ATN)*	Edition 3 / November 2001	
ICAO Annex 10	*International Standards and Recommended Practices (SARPs)* *- Volume III*	Amendment 75 / Nov. 2001 Amendment 72+	Part I, Chapter 6 Part II, Chapter 2
ICAO Annex 10	*International Standards and Recommended Practices (SARPs)* *- Volume V*	Amendment 75	Chapter 4
ICAO Doc X	*Manual on VHF Digital Link (VDL) Mode 3 Technical Specifications*	Nov 2001	
ICAO Doc X	*Manual on the Implementation of the Very High Frequency (VHF) Digital Link Mode 3 (VDL Mode 3)*	Nov 2001	

2.2.2 Industry Standards

[5] Supercedes EO 12902.

Doc No.	Document Title	Version / Date	Sections
RTCA DO-178B	*Software Considerations in Airborne Systems and Equipment Certification*	December 1, 1992	
RTCA DO-248a	*Second Annual Report for Clarification of DO-178B "Software Considerations in Airborne Systems and Equipment Certification"*	September 13, 2000	
RTCA DO-186a	*Minimum Operational Performance Standards for Airborne Radio Communications Equipment Operating Within the Radio Frequency Range 117.975-137.000 MHz (MOPS)*	October 20, 1995	
RTCA DO-224A	*Signal-in-Space Minimum Aviation System Performance Standards (MASPS) for Advanced VHF Digital Data Communications Including Compatibility with Digital Voice Techniques*	September 13, 2000	2.0, 3.3, 3.4, 3.5, 3.10, 3.11
RTCA DO-225	*VHF Air-Ground Communications System Improvements Alternatives Study and Selection of Proposals for Future Action*	November 1994	
NFPA Standard 70	*National Electrical Code*		6.2
ANSI/IEEE 1100-1992	*IEEE Recommended Practice for Powering and Grounding Electronic Equipment*	1999	
ANSI/IEEE C62.31-1987	*Gas-Tube Surge-Protection Devices*	1987	
ANSI/IEEE C62.36-1994	*Surge protectors used in Low-Voltage Data Communications, and Signaling Circuits*	1994	
ANSI/IEEE C62-41-1991	*IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*	1991	
ANSI/IEEE C95.1-1991(R-97)	*Standard Safety Levels With Respect To Human Exposure To Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*	1999	
ANSI/IEEE 519-1992	*IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*	1992	
ANSI T1.403	*American National Standard for Telecommunications - Carrier-to-Customer Installation – DS1 Metallic Interface*	1999	
EN-300-676	*EMC and Radio Matters (ERM); Hand Held Mobile and Fixed Transmitters, Receivers, and Mobile Service using Amplitude Modulation; Technical Characteristics and Methods for Measurement.*		
ITU-T G.824	*Digital Networks-The Control of Jitter and Wander within Digital Networks which are Based on the 1544 kbit/s Hierarchy*	March 1993	

2.3 Order of Precedence

When the requirements of this document and referenced applicable documents are in conflict, this document **shall** have precedence over all documents referenced herein.

2.4 Availability of Documents

2.4.1 FAA Documents

Copies of FAA specifications, standards, and publications may be obtained from the NEXCOM Contracting Officer, FAA, 800 Independence Avenue SW, Washington, DC 20591. Requests should clearly identify the desired material by number and state the intended use of the material. Revision FAA-G-2100G may be downloaded from the FAA at http://www.faa.gov/asd/standards/index.htm.

2.4.2 Federal Documents

Copies of federal publications may be obtained from the US Government Printing Office, 710 North Capitol Street, Washington DC, 20401, by calling (202) 512-0132, or through the web site http://bookstore.gpo.gov/.

2.4.3 International Civil Aviation Organization Documents

Copies of ICAO documents may be obtained from the ICAO Library, 999 University Street, Montreal, Quebec H3C 5H7, Canada.
Note: For current working documents that are not final products, inquire at ICAO web site http://www.icao.org.

2.4.4 RTCA, Inc. Documents

Copies of RTCA, Inc. documents may be obtained from RTCA, Incorporated, 1828 L Street N.W., Suite 805, Washington, DC 20036-4001, by phone (202) 833-9339, or through the web site http://www.rtca.org.

2.4.5 IEEE Documents

Institute of Electrical and Electronics Engineers (IEEE) documents may be ordered from the IEEE Computer Society Press. Ordering information is available over the Internet at http://www.computer.org/cspress/order.htm or by calling (800) 272-6657.

2.4.6 ANSI Documents

American National Standards Institute (ANSI) and International Organization of Standardization (ISO) documents may be obtained from the American National Standards Institute, 11 West 42nd Street, New York, NY, 10036, or through the web site http://www.ansi.org.

3 REQUIREMENTS

3.1 Functional System Description

This section provides an overview and serves as an introduction to the requirements stated in the SRD. For a better understanding of the current system see Appendix A, and for the proposed future system see Appendix B.

NEXCOM will support a voice and data communications capability that meets the emerging needs of the FAA's A/G communications in the areas such as system capacity, reliability, maintainability, availability, and voice and data quality. A simplified representation of the NEXCOM System is shown in figure 3-1. The system will be capable of operating in the currently allocated Aeronautical Mobile (Route) Services (AM(R)S) spectrum (117.975 to 137 MHz). The NEXCOM System can operate either in Double-Sideband Amplitude Modulation (DSB-AM) or VHF Digital Link (VDL) Mode 3; VDL Mode 3 can provide up to four separate time slots in each existing 25-kHz-wide frequency assignment.

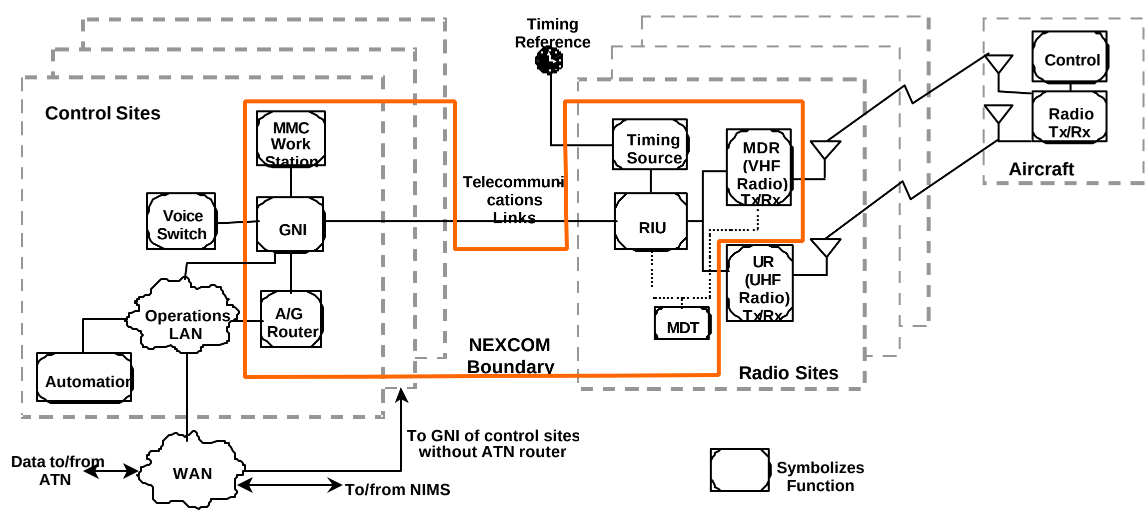


Figure 3-1 NEXCOM System Overview

The NEXCOM System includes both control site and remote site capabilities.

In a control site, NEXCOM connects to a voice switch through a Ground Network Interface (GNI); the GNI also serves a connection to Air Traffic (AT) data, which are inserted into NEXCOM through A/G Routers. The Aeronautical Telecommunications Network (ATN) data are routed through a Wide Area Network (WAN); at the control site the WAN connects to the site Local Area Network (LAN).

In a remote communications facility (shown as Radio Site in Figure 3-1) NEXCOM will include an RIU(s), which can control MDR transmitters, MDR receivers, UHF transmitters, and UHF receivers.

NEXCOM also includes a timing function, which receives highly accurate clocking and is capable of synchronizing radio sites. A portable Maintenance Data Terminal (MDT) is used for on-site maintenance and parameter adjustment.

The connection between the GNI at control facilities and RIUs at radio sites is external to the NEXCOM boundary; in general the connectivity comprises telecommunications links, usually provided by leased Telecommunication services.

3.1.1 Functional System Elements

The NEXCOM System includes the following elements:

1. Multimode Digital Radio (MDR)
2. Radio Interface Unit (RIU)
3. Ground Network Interface (GNI)
4. A/G Router
5. Timing Source
6. Maintenance, Monitoring and Control Workstation (MMCWS)
7. Maintenance Data Terminal (MDT)

3.1.1.1 MDR Transmitter and Receiver

An MDR is either a radio transmitter or a radio receiver.

1. The MDR is located at radio sites (remote or local)
2. The MDR can operate in ICAO defined analog or digital modes
3. In digital mode, multiple Talk Groups can share a common frequency with different time slot assignment

3.1.1.2 RIU

1. The RIU is located at radio sites[6]
2. The RIU controls both the Very High Frequency (VHF)[7] MDR units and the Ultra High Frequency (UHF)[8] DSB-AM radios
3. The RIU interfaces with the GNI via telecommunications links
4. The RIU is the conduit for NEXCOM MMC data between the radio site and the control site
5. The RIU provides timing for the MDR in the VDL Mode 3 operation

3.1.1.3 GNI

1. The GNI is located at the control sites
2. The GNI interfaces to the voice switch
3. The GNI interfaces to the A/G Router
4. The GNI integrates voice and data
5. The GNI is the conduit for NEXCOM MMC data between the radio site and the control site
6. The GNI connects MMC data to NIMS
7. The GNI interfaces to the RIU via telecommunications links

[6] In general the RIU is collocated with the MDR transmitter and receiver. However, in STR configurations separate RIUs may be used to support the separated transmitters and receivers.
[7] In this context VHF means the frequency band 117.975 to 137 MHz.
[8] In this context UHF means the frequency band 225 to 400 MHz.

3.1.1.4 A/G Router

1. The A/G Router is located at selected control sites
2. The A/G Router interfaces to the ATN
3. An A/G Router may provide an interface for more than one GNI

3.1.1.5 Timing Source

1. The timing source is located at the radio sites
2. The timing source provides highly accurate and stable clocking to the RIU
3. The timing source is used by the RIU to maintain system timing

3.1.1.6 MMC Workstation

1. The MMCWS is a fixed NEXCOM local workstation
2. The MMCWS provides MMC capability from a fixed workstation for all NEXCOM components
3. The MMCWS connects to the GNI

3.1.1.7 MDT

The MDT is a software application that resides in a portable platform that is temporarily connected to the MDR or RIU.

1. The MDR-MDT performs MMC for the MDR
2. The RIU-MDT performs MMC for the RIU(s) and remote MMC for the MDR and the UHF radio

3.1.2 System Interfaces

The following subsections describe NEXCOM System interfaces. Figure 3-1 shows the NEXCOM System boundary. There are external interfaces (NEXCOM to systems external to the boundary) and internal interfaces that are inside the NEXCOM System boundary.

3.1.2.1 Internal Interfaces

The NEXCOM System internal interfaces are interfaces among NEXCOM elements. The internal interfaces include the following:

1. MDR Receiver/RIU
2. MDR Transmitter/RIU
3. GNI/RIU
4. GNI/Air/Ground Router
5. GNI/MMC Workstation
6. MDT/RIU
7. MDT/MDR Receiver
8. MDT/MDR Transmitter
9. GNI/GNI
10. RIU(s)/Timing Source

3.1.2.2 External Interfaces

The key NEXCOM external interfaces can be identified from figure 3-1 as follows:

1. Antennas
2. Timing Reference
3. Voice Switch
4. Telecommunications links at the radio sites and at the control sites
5. Site LAN (this includes interfaces to the ATN, NIMS, and other control sites through the WAN, as well as an interface to site automation)
6. UHF Radio Receiver
7. UHF Radio Transmitter

3.2 NEXCOM System Functional Requirements

The NEXCOM System functional requirements that support integrated voice and data Air/Ground Communications are described in the following subsections. The corresponding system performance requirements are described in section 3.3.

3.2.1 Integration Within the NAS

The following subsections provide the requirements for integration of the NEXCOM System into the NAS.

3.2.1.1 Existing Facility

3.2.1.1.1 Site Configurations

a) The NEXCOM System **shall** support the following site configurations:

1. Single RCF
2. Separated transmitter/receiver sites
3. Primary RCF with backup site (e.g., BUEC)
4. Diversity site group
5. Dual control

Note: See Section 3.2.3.5 and Appendix A, Sect. A.3.2.2 for an explanation of diversity site group. See Section 3.2.3.6.7 and Appendix A, Sect. A.3.2.1 for an explanation of dual control.

3.2.1.1.2 NAS ATS Facility Compatibility

a) The NEXCOM System **shall** operate within existing NAS ATS Facilities.

Note 1: The goal is to not require modification to existing infrastructure support (i.e., HVAC, power, grounding, bonding, shielding and lightning protection).
Note 2: This means that the NEXCOM System must not generate harmful interference.

3.2.1.2 Coexistence

3.2.1.2.1 Coexistence with the Present System

a) All NEXCOM modes specified in Section 3.2.2.a. **shall** coexist with the current VHF/UHF DSB-AM system throughout the NAS.

Note: This means that the NEXCOM System must not generate harmful interference to Air/Ground Communications.

3.2.1.2.2 Coexistence Among NEXCOM Modes

a) All NEXCOM modes specified in Section 3.2.2.a. **shall** coexist with all NEXCOM modes throughout the NAS.

3.2.1.2.3 Coexistence with other Existing Systems

a) The NEXCOM System **shall** coexist with any existing FAA systems.

Note: The NEXCOM System must not generate harmful interference to other FAA systems (e.g., navigation, landing, and surveillance), and the NEXCOM System must also operate under the existing RFI environments.

3.2.2 Modes of Operation

a) The NEXCOM System **shall** operate in each of the following selectable modes:

1. VDL Mode 3
2. 25 kHz DSB-AM [RD 2.1; RD 5.3.2; RD 10.2.1]
3. 8.33 kHz DSB-AM

Note 1: The 25kHz DSB-AM mode of operation allows for and supports the transition of the NEXCOM System from analog voice to an integrated VDL Mode 3 digital voice and data solution.
Note 2: This requirement allows for the use of 25 kHz DSB-AM emergency communication channels (121.5 MHz) even when in VDL Mode 3 operation and is a dedicated voice service.
Note 3: The 8.33 kHz DSB-AM mode of operation allows for a programmatic fall back and may be removed from this document at a later date.

b) The NEXCOM System **shall** operate a UHF DSB-AM mode simultaneously with VHF modes in each User Group as needed.

c) The NEXCOM System **shall** meet United States regulatory functional requirements specified in FCC (Part 2 and 87), NTIA (Chapters II, V, VII, X, and ANNEX B).

3.2.2.1 VDL Mode 3 Standardization

a) The NEXCOM System **shall** meet the VDL Mode 3 functional requirements for ground systems specified in RTCA DO-224A.

3.2.2.2 25 kHz DSB-AM Standardization

a) The NEXCOM System **shall** meet the 25 kHz DSB-AM functional requirements specified in FAA-P-2883 and FAA-P-2884.

3.2.2.3 8.33 kHz DSB-AM Standardization

a) The NEXCOM System **shall** meet the 8.33 kHz DSB-AM functional requirements specified in ICAO Annex 10 and ETSI specification EN-300-676.

3.2.2.4 Channel Labeling

a) The NEXCOM System **shall** operate with the ICAO channel labeling for each of the modes identified in section 3.2.1.a.

Note: This channel labeling requirement implies additional requirements on other NAS databases such as the Voice switches and automation systems.

3.2.3 User Group Communications

The following subsections provide requirements for User Group communications.

3.2.3.1 Voice Communications Requirements

a) The NEXCOM System **shall** allow all users in a Talk Group to monitor all voice communications within that Talk Group. [RD 3.1.1.2]

Note 1: This requirement is fulfilled by the proper implementation of the modes of operation specified in section 3.2.2.
Note 2: This requirement does not require the rebroadcast of voice traffic when the system is configured to operate on multiple frequencies for a single sector/control airspace.

b) Overloading of data communication **shall** not prevent the operation of voice communication.

c) The NEXCOM System **shall** route received audio to the output at the VSCE based on the received audio at the remote site.

Note 3: This should be interpreted to mean if audio is received on the VHF input at the remote site it should be routed to the VHF audio output at the control site (and the same for UHF). It should also be noted that this configuration is only defined when more than one audio output is utilized at the control site.

3.2.3.1.1 Voice Channels

a) The NEXCOM System **shall** interface with existing VSCS (e.g., VSCS, ETVS, ICSS, RDVS, STVS) via existing interfaces (e.g., Single channel (V+U) and quad channel (V/U/M/S)). [FAA-E-2885]

3.2.3.1.2 Voice Encoding/Decoding

a) The NEXCOM System/VSCE interface **shall** include:

1. Analog voice
2. Digital voice

b) Voice encoding/decoding for VDL Mode 3 **shall** be in accordance with the vocoder algorithm specified in ICAO Annex 10, Vol. III, Part 1, Chapter 6.

3.2.3.1.3 Voice Path

3.2.3.1.3.1 Uplink Path

a) The NEXCOM System **shall** transmit uplink voice out of the radio at the site(s) selected by the controller.

3.2.3.1.3.2 Downlink Path

a) The NEXCOM System **shall** route all downlink voice output from all selected receivers to the VSCE.

Note: The current system delivers all downlink voice outputs to the VSCE.

3.2.3.1.3.2.1 Local Audio Monitoring

a) The NEXCOM System **shall** present the downlink voice, in an analog format, received at the radio site for local monitoring at the remote site.

b) The NEXCOM System **shall** present the uplink voice, in an analog format, received and the remote site for local monitoring at the remote site.

c) The NEXCOM System **shall** present the downlink voice, in an analog format, received at the control site for local monitoring at the control site.

d) The NEXCOM System **shall** present the uplink voice, in an analog format, received at the control site for local monitoring at the control site.

3.2.3.2 Data Communications Requirements

The following requirements are only applicable when the NEXCOM System is operating with the VDL Mode 3 service.

3.2.3.2.1 Data Service

a) The NEXCOM System **shall** provide for a subnetwork for two-way addressed data communications between ground and aircraft systems. [RD Att 2]

b) The NEXCOM System **shall** provide for uplink broadcast using the same subnetwork as the two-way addressed service. [RD Att 2]

Note: This includes providing an uplink data broadcast subnetwork without supporting two-way service.

3.2.3.2.1.1 ATN Compatibility

a) The NEXCOM System **shall** interoperate with ATN-based Air/Ground Routers and avionics routers as defined in the ICAO Annex 10, and ICAO Doc 9705 (Edition 3).

3.2.3.2.1.2 Make-before-Break Support

a) The NEXCOM System **shall** support Make-before-Break (MbB) capabilities as described in RTCA DO-224A, Section 3.3.3.3.

3.2.3.2.1.3 User Authentication

a) The NEXCOM System **shall** support authentication of user attempts to initialize connections per RTCA DO-224A, Section 3.3.2.3.2.8. [RD 7.3.1.1]

Note: This requires the development of a Public Key Infrastructure (PKI) to distribute keys to the system users.

b) The NEXCOM System **shall** limit access to unauthorized parts of the NAS external to the NEXCOM System. [RD Att 2]

3.2.3.3 Continuous Broadcast

a) The NEXCOM System **shall** provide continuous ground-to-air broadcast within a service volume for the modes identified in section 3.2.2.

Note: This applies to both voice and data broadcasts.

3.2.3.4 Connectivity

3.2.3.4.1 Entry Into a Talk Group

a) The NEXCOM System **shall** allow any aircraft operating in the correct mode entry into any Talk Group within the Talk Group's service volume. [RD 3.1.1.3]

Note: This is to ensure that the aircraft can enter a Talk Group regardless of whether or not the aircraft was instructed to do so by the ground controller. For example, in the case where the aircraft has lost communication with its own Talk Group, it should still be able to access another Talk Group.

3.2.3.4.2 Automated Transfer of Communication

a) The NEXCOM System **shall** upload channel assignment information to an aircraft system via the VDL Mode 3 Next Net capability defined in RTCA DO-224A. [RD Att 2]

Note: This requirement is intended to support Transfer of Communication (TOC) via Next Net messaging.

3.2.3.4.3 Subnetwork Connectivity Reporting

a) The NEXCOM System **shall** report to the A/G Router only those connectivity changes to the subnetwork that affect the A/G Router connectivity decisions. [ICAO Doc 9705]

Note: This requirement is intended to allow the option of the subnetwork masking certain connectivity changes from the router to prevent excessive Inter-Domain Routing Protocol (IDRP) updates to the system.

3.2.3.5 Ground Station Operations

a) The NEXCOM System **shall** support diversity site group operation (See Appendix A).

When operating in VDL Mode 3:

b) The NEXCOM System **shall** schedule the VDL Mode 3 uplink M-Burst of the ground transmitters to avoid self-interference. [SRD 3.2.1]

Note 1: This is necessary to allow only one Beacon transmission per M burst for the User Group in order to sequence Beacons from diverse sites in a User Group (e.g., RCAG and BUEC).

c) In any User Group, the active transmitter Beacon **shall** not cause harmful interference with any other NEXCOM Subsystems operating on the same frequency. [SRD 3.2.1]

Note 2: This applies to all Main, Standby and BUEC NEXCOM Subsystems at all sites supporting the subject service.

3.2.3.6 NEXCOM System Signaling and Control

Note: The display of information to the controller is the responsibility of the appropriate external system. NEXCOM is responsible only for making the information available to the interface.

3.2.3.6.1 PTT Control

a) The NEXCOM System voice channel uplink access **shall** be based on PTT assertion. [RD 3.1.4]

b) The NEXCOM System **shall** provide confirmation of PTT/PTT Release on a Talk Group basis. [RD 3.1.7.1]

Note 1: The activation of the Ground Stuck Microphone Correction function, used to disable NEXCOM RF transmissions, releases the PTT signal and will cause the PTT Confirmation to be de-asserted.

c) The NEXCOM System **shall** be configurable to provide confirmation of PTT/PTT Release based on the reception of the transmitted signal. [RD 3.1.7.1]

Note 2: This capability provides a means to monitor whether transmitters are actually radiating when the receiver is close enough to the transmitter to allow the receiver to indicate sufficient RF power is being produced.

3.2.3.6.2 Preemption of Aircraft Voice Transmissions

When operating in VLD Mode 3:

a) The NEXCOM System **shall** provide a selectable function that allows the controller to preempt aircraft voice transmissions on a per Talk Group basis as follows. [RD 3.3.1; RD 3.3.2; DO 224A, 9/13/01, 3.3.2.1.1.1]

1. Preemption Off (function disabled)
2. Preemption On (Upon PTT activation preemption occurs)
3. Momentary Preemption on a single PTT basis (Dynamic function selectable by the controller)

Note 1: This pre-emptive access provides a limited capability to cope with various operational issues including the "stuck" microphone condition by allowing authorized ground users to deactivate the transmitter of the offending user.
Note 2: The voice preemption function (also referred to as controller override) is activated only when the PTT is asserted.

b) The NEXCOM System **shall** provide confirmation to the VSCE of the assertion of preemption of aircraft voice transmission by the ground station for the duration of the preemption.

3.2.3.6.3 Squelch Break

a) The NEXCOM System **shall** squelch background noise in the absence of a signal that is above a preset threshold.

b) The NEXCOM System **shall** provide squelch break indication on the selected receivers for the duration of the squelch break to the control facility. [RD 3.1.7.1]

3.2.3.6.4 Received Audio Muting

Note: Mute is infinite attenuation for the requirements below.

3.2.3.6.4.1 PTT Mute/Attenuation

For VDL Mode 3 mode of operation:

a) The NEXCOM System **shall** be configurable (on a per Talk Group basis) to mute (at the control site) any received uplink audio (provided to the VSCE) interface.

For DSB-AM modes of operation:

b) The NEXCOM System **shall** be configurable (on a per Talk Group basis) to mute (at the control site) downlink audio (provided to the VSCE interface) during the assertion of PTT.

c) The NEXCOM System **shall** be configurable (on a per Talk Group basis) to attenuate (at the remote site) downlink audio during the assertion of PTT.

d) The NEXCOM System **shall** be configurable (on a per Talk Group basis) to continue to attenuate (at the remote site) downlink audio during the release of PTT (for up to 600 ms, 0 to 600 ms in 10 ms increments).

3.2.3.6.4.2 Command Mute

a) The NEXCOM System **shall** support mute/unmute of the received audio (at the radio site)(on a per Talk Group basis) based on the operator input. (e.g., VSCE, MMC, etc.)

b) The NEXCOM System **shall** provide confirmation of the received audio muting/unmuting (at the radio site) to the operator. (e.g., VSCE, MMC, etc.)

3.2.3.6.5 Ground Radio Selection and Switching

3.2.3.6.5.1 Radio Selection

a) The NEXCOM System **shall** select radio resources (i.e., Main, Standby, and BUEC transmitters and receivers) for voice operation based on the operator input (e.g., VSCE, MMCWS, and/or MDT).

b) The NEXCOM System **shall** provide confirmation on radio resource selection to the Operator (e.g., VSCE, MMCWS, and/or MDT) upon completion of radio switching.

c) The NEXCOM System **shall** support independent selection of radio resources for voice operation by different Talk Groups.

d) The NEXCOM System **shall** cause no loss of management and user information due to selection of radio resources for voice operation.

e) When any PTT is activated, the NEXCOM System **shall** inhibit the radio resource select functions for that Talk Group (i.e., inhibit the re-routing of the voice and control signals and inhibit the switching of the antenna transfer relay). [FAA-E-2885 Section 3.2.2.3.1 Shall#25]

3.2.3.6.5.2 Automatic Radio Switching

a) When the Main and Standby radios are serviced by the same RIU, and so configured, the NEXCOM System **shall** automatically perform M/S radio switching from the selected to the alternate radio, without operator intervention, in the event of a failure of the selected radio. [RD 3.1.9.1, Att2 Automatic Failure Detection and Fault Isolation]

Note 1: The intent of this requirement is to reduce controller workload by making use of the system's ability to detect and isolate radio failures and switch to the alternate unit, if available and so configured.
Note 2: In the case of automatic radio switching upon failure, all User Groups operating on the failed radio will be switched to the alternate radio automatically including, voice, data, and management traffic.

b) The automatic M/S radio switching function **shall** be disabled by subsequent operator manual M/S radio selection.

c) If the automatic M/S radio switching function is disabled by subsequent operator manual M/S radios selection, the automatic M/S radio switching function **shall** remain disabled until manually reset.

d) Automatic radio switching **shall** only be performed when the alternate radio is operational.

Note 3: The Automatic Radio Switching function is intended to apply to both the MDR and the UHF radios connected to the NEXCOM System.

3.2.3.6.6 Channel Busy Signal

a) The NEXCOM System **shall** provide a signal to the VSCE that the channel keyed by the controller is occupied by a downlink transmission.

Note 1: This requirement is needed in support of the voice transmit function of VLD Mode 3 described in RTCA DO-224A Section 3.3.5.4.3.
Note 2: This function is needed in support of dual control. See also SRD Section 3.6.1.2.
Note 3: Channel Busy does not apply to the receipt of your own transmission.

3.2.3.6.7 Dual Control

a) The NEXCOM System **shall** provide a dual control priority mode to share control of a Talk Group by two different control facilities. [FAA-E-2885, 3.2.2.3.1.3]

b) The NEXCOM System **shall** provide a dual control non-priority mode to share control of a Talk Group by two different control facilities. [FAA-E-2885, 3.2.2.3.1.3]

Note: Dual control is currently employed via the RCE. In this configuration two separate control sites are capable of controlling the same frequency from a single remote site. In the case of priority mode, the higher priority of one facility over the other is determined operationally by the facilities themselves, and it is not the function of the NEXCOM System to determine priorities.

3.2.3.6.7.1 Priority Mode

In this mode, one of the control facilities is designated to be the primary facility. Subsequently:

a) Each control facility **shall** be defined as either a primary or secondary for the paired Talk Group. [FAA-E-2885, 3.2.2.3.1.3.2]

Note: This means each control facility cannot be primary for one Talk Group and secondary for the other in a paired Talk Group. Paired Talk Groups are commonly composed of a VHF Talk Group and a UHF Talk Group.

b) The primary control facility **shall** lockout the secondary control facility during transmission. [FAA-E-2885, 3.2.2.3.1.3.2]

c) During the transmission by the primary facility, a lockout signal **shall** be provided back to the secondary control facility. [FAA-E-2885, 3.2.2.3.1.3.1]

d) The NEXCOM System **shall** provide a PTT confirmation signal back to both control facilities. [FAA-E-2885, 3.2.2.3.1.3.2]

e) The primary control facility PTT **shall** override the secondary control facility voice communication on the shared Talk Groups. [FAA-E-2885, 3.2.2.3.1.3.2]

f) The communication on the receive path **shall** always be open to both facilities. [FAA-E-2885, 3.2.2.3.1.3.2]

g) When the mute function is selected, the facility **shall** mute its own receive path independent of the mute selection of the other facility. [FAA-E-2885, 3.2.2.3.1.3.2]

h) The selection of the mute for one Talk Group **shall** be independent of the other Talk Group.

i) The site not asserting PTT **shall** hear the other site's transmit audio.

j) Upon termination of transmission by the primary facility, the lockout condition to the secondary facility **shall** be removed automatically. [FAA-E-2885, 3.2.2.3.1.3.2]

3.2.3.6.7.2 Non-Priority Mode

In this mode, both control facilities have equal priority, subsequently:

a) The NEXCOM System **shall** provide a transmission path for the control facility that initiated the transmission first**.** [FAA-E-2885, 3.2.2.3.1.3.1]

b) The NEXCOM System **shall** provide a confirmation signal back to the control facility that initiated the transmission first. [FAA-E-2885, 3.2.2.3.1.3.1]

c) During the transmission by one facility, the second facility **shall** be locked out. [FAA-E-2885, 3.2.2.3.1.3.1]

d) During the transmission by one facility, a lockout signal **shall** be provided back to the secondary control facility. [FAA-E-2885, 3.2.2.3.1.3.1]

e) The communication on the receive path **shall** always be available to both facilities. [FAA-E-2885, 3.2.2.3.1.3.1]

f) When the mute function is selected, the facility **shall** mute its own receive path independent of the mute selection of the other facility. [RD 10.2.1.1; FAA-E-2885, 3.2.2.3.1.3.1]

g) Upon the termination of transmission by the facility that initiated the transmission, the lockout condition to the other facility **shall** be removed**.** [FAA-E-2885, 3.2.2.3.1.3.1]

3.2.3.7 Ground Stuck Microphone Correction

a) The NEXCOM System **shall** provide a function which can be enabled, that disables transmission by a specific ground MDR. [RTCA/DO 224A, 3.3.2.1.1.1; RD 3.3.1; 3.3.2]

b) This transmission disabling function **shall** have a configurable time component so that when the duration of that MDR's keying input exceeds the configured time, transmission stops. [RTCA/DO-224A; 3.3.2.1.1.1; RD 3.3.1; RD 3.3.2]

c) The NEXCOM System **shall** allow the controller to reinitiate the transmission after this function has disabled transmission by releasing the PTT command and reapplying it. [RD 3.3.1; 3.3.2; RTCA/DO 224A, 3.3.2.1.1.1]

Note 1: The NEXCOM System indicates the disabling of the transmission to the controller via the removal of PTT Confirmation.
Note 2: Activation of this function will disable PTT and if preempting, will stop the preemption.

3.2.3.8 Telecommunications Links

The following defines the telecommunications requirements needed to support NEXCOM communications between facilities:

3.2.3.8.1 NEXCOM/Telecommunications Interfaces

a) The NEXCOM System telecommunications **shall** provide full-duplex operation.

b) The NEXCOM System **shall** operate with existing 4-wire analog telecommunications and selected digital telecommunications between control and remote radio facilities.

Note 1: *Information on digital telecommunications for NEXCOM will be defined in the NEXCOM/Telecommunications ICD.*
Note 2: *The following is a list of the analog and digital Telecommunications (further defined in FAA Communications Installation Handbook 6580.3A) currently in use:*

1. *VG-6 voice grade circuits*
2. *VG-8 voice grade circuits*
3. *The FAA Radio Communications Link (RCL)*
4. *The FAA Low Density Radio Communications Link (LDRCL)*
5. *The FAA Telecommunications Satellite (FAATSAT) Link*
6. *The Alaskan NAS Interfacility Communications System (ANICS)*
7. *Field cable*
8. *Fiber*

Note 3: Multiple analog telecommunications circuits may be required to provide sufficient bandwidth to support all four groups of the VDL Mode 3 radio. For example, if only 9600 bps service can be achieved with each available VG-6 circuit, then four or more circuits will be required to support a VDL Mode 3 radio with al of its user groups active.

c) Analog telecommunications **shall** meet the interface requirements as specified in *Bellcore TR-NWT-000335 Voice Grade Special Access Service Transmission Parameter Limits and Interface Combinations, May 1993*.

d) Digital telecommunications **shall** meet the interface requirements specified in *Bellcore GR-499-CORE Transport Systems Generic Requirements (TSGR) Common Requirements, December 1998*.

e) The NEXCOM System **shall** support three telecommunication link redundancy configurations:

1. No backup
2. Standby backup
3. Hot telecommunications backup

Note 4: Multiple telecommunications circuits may be required to comprise a single telecommunications link. For example, multiple VG-6s may service a single RIU to communicate the different user group information.
Note 5: The hot backup configuration is only applicable when redundant telecommunications are available and the worst-case delay of the links is considered acceptable.
Note 6: The standby backup configuration is applicable when redundant telecommunications are available regardless of the relative delays on the links.

3.2.3.8.2 Telecommunications Restoration Functional Requirements

The following functional requirements are related to restoration of NEXCOM service between the primary telecommunications link and its backup.

a) The NEXCOM System **shall** have a selectable function to restore service over the original telecommunications link, for telecommunications service interruption of less than 3 seconds in duration.

b) When a backup telecommunications link is available, the NEXCOM System **shall** have a selectable function to restore service over the backup telecommunications link automatically upon detection of the primary telecommunications link failure for telecommunications link service interruption that is 3 seconds or longer in duration.

c) Upon confirmation of restoration of the primary telecommunications link, the NEXCOM System **shall** switch its operation back from the backup telecommunications link to the primary telecommunications link automatically.

d) When both telecommunications links are functioning properly, the automatic switch back to the primary telecommunications link **shall** be disabled until PTT is de-asserted.

3.2.3.8.2.1 Standby Telecommunications Restoration Functional Requirements

The following functional requirements are related to restoration of NEXCOM service between the primary telecommunications and its backup for the standby telecommunications backup configuration.

a) The NEXCOM System **shall** restore service over the original telecommunications link, for telecommunications service interruption of less than 1 second in duration.

b) When a backup telecommunications link is available, the NEXCOM System **shall** have a selectable function to restore service over the backup telecommunications link automatically upon detection of the primary telecommunications link failure for a telecommunications link service interruption that is 1 second or longer in duration.

c) Upon confirmation of restoration of the primary telecommunications link and so configured, the NEXCOM System **shall** switch its operation back from the backup telecommunications link to the primary telecommunications link automatically.

d) When both systems are functioning properly, the automatic switch back to the primary telecommunications link **shall** be disabled until the PTT is de-asserted.

3.2.3.8.2.2 Hot Telecommunications Backup Functional Requirements

The following functional requirements are related to NEXCOM service operating with redundant telecommunications while in the hot telecommunications backup configuration.

a) Failure or any performance degradation to either one of the telecommunications interfaces in the hot backup configuration **shall** not degrade the NEXCOM System operation.

3.2.4 Maintenance, Monitoring and Control (MMC) Functional Requirements

The NEXCOM MCC system is based on a three-level hierarchy with the GNI at the top of the hierarchy, the RIU in the middle, and the MDR at the bottom (See Appendix B for the NEXCOM MCC System Hierarchy). Unless otherwise stated the following control and monitoring hierarchy applies:

a) The NEXCOM System **shall** follow the following MMC hierarchy rules for control and monitoring:

1. Higher level subsystems have control and monitoring over lower level subsystems, i.e., GNI controls and monitors its RIU and MDR, and RIU controls and monitors its MDRs.
2. Equal level subsystems do not have control over each other, i.e., GNIs do not control each other, RIUs do not control each other, and MDRs do not control each other.
3. An RIU can monitor, through the GNI, its associated diversity site RIU/MDRs, but other equal level subsystems to not monitor each other, i.e., GNIs do not monitor each other, RIUs not associated together do not monitor each other, and MDRs do not monitor each other.
4. Lower level subsystems do not have control over higher level subsystems, i.e., MDR does not control RIU and GNI.
5. An RIU can monitor the GNI associated with that particular Talk Group, but other lower level subsystems do not monitor higher level subsystems, i.e., MDR does not monitor RIU and GNI.

Note: A MDT can access NIMS remotely via a dial up connection from a remote radio site to control the NEXCOM System, provided that the maintenance personnel at the remote site has the proper control authority.

3.2.4.1 Maintenance Requirements

The following maintenance requirements apply to each NEXCOM Subsystem.

3.2.4.1.1 General Maintenance Requirements

a) The NEXCOM System **shall** meet the hardware maintenance requirements specified in FAA Order 6000.30C, National Airspace System Maintenance Policy. [RD 5.1.2]

Note 1: This policy details a two-level maintenance philosophy: field and depot.

b) For DSB-AM modes of operation, NEXCOM equipment **shall** be maintained with the support equipment, test equipment, and tools presently in the FAA inventory. [RD 8.3.1]

Note 2: For new modes of operation (i.e., VDL Mode 3), new test equipment is being developed to support maintenance of the equipment.

c) Individual Lowest Replaceable Units (LRUs) **shall** be designed to permit removal and replacement by a single person. [RD 6.2.4]

3.2.4.2 Access

a) Access to MMC functions **shall** be by the following means: [RD 5.1.2]

1. Local MMC Access (See Section 3.2.4.2.1)
2. Remote MMC Access (See Section 3.2.4.2.2)

Note 1: See Figures B-6 and B-6a of Appendix B for local and remote relationships in the NEXCOM MMC System Hierarchy.

b) The NEXCOM System **shall** permit simultaneous monitoring from all remote and local access points in accordance with 3.2.4a). [RD 5.1.2]

c) Local control access **shall** automatically inhibit remote control access. [RD 5.1.2]

d) The NEXCOM System **shall** provide multiple privilege levels to control access to the NEXCOM MMC. [SRD 3.3.4.2; 3.4.6.3.4]

Note 2: This requirement allows the NEXCOM System control of the MMC function to accommodate different classes of users with appropriate MMC capabilities consistent with the assigned responsibilities and to minimize the overall security risk to NEXCOM.

e) The MCC functions associated with each privilege level **shall** be configurable. [SRD 3.3.4.2; 3.4.6.3.4]

3.2.4.2.1 Local MMC Access

a) The local MMC access point **shall** provide authorized on-site personnel access to the MMC functions of NEXCOM Subsystems that the on-site personnel is directly connected to, which allows the on-site personnel to carry out diagnostic activities, adjust parameters, and maintain proper operation of the equipment. [RD 5.1.2]

3.2.4.2.2 Remote MMC Access

a) Remote MMC **shall** provide authorized personnel access to the MMC functions of indirectly connected NEXCOM Subsystems to carry out diagnostic activities, adjust parameters, and maintain proper operation of the equipment in accordance with 3.2.4a). [RD 5.1.2]

b) Remote MMC **shall** provide the same functionality and capabilities as local MMC functions except for the local audio interface. [RD 5.1.2]

Note: NIMS is Remote MMC Access.

3.2.4.2.3 MMC Access Security

a) The NEXCOM System **shall** support the assignment of a unique logon identifier for each logged user.

b) The NEXCOM System **shall** authenticate the claimed user's identity before allowing the user to perform any actions.

c) When passwords are used for authentication, the NEXCOM System **shall** use strong passwords (i.e., prevent the use of dictionary words).

d) The NEXCOM System **shall** enforce mandatory password changes at set intervals.

e) The NEXCOM System **shall** prevent the reuse of passwords on a per user basis.

f) The NEXCOM System **shall** execute a defined access control policy.

Note 1: This requirement may duplicate other requirements in this document.

g) The NEXCOM System **shall** enable access authorization management; i.e., the initialization, assignment, and modification of access rights (e.g., read, write, execute) to MMC functions with respect to (1) group membership (privilege level); and such constraint as port-of-entry.

h) The NEXCOM System **shall** enforce separation of duties through its role-based ability to restrict users to specific MMC functions and to specific actions on those objects.

Note 2: This requirement is based on the privilege levels. This requirement may duplicate other requirements in this document.

i) The NEXCOM System **shall** provide resource allocation features having a measure of resistance to resource depletion (mitigate denial of service attacks).

j) The NEXCOM System **shall** temporarily (a configurable period of time) suspend user accounts after a configurable number of consecutive failed logon attempts.

k) The NEXCOM System **shall** display a configurable banner page upon login.

l) The NEXCOM System **shall** protect information system security data and functionality from all unauthorized access.

3.2.4.2.4 NEXCOM/NIMS Interfaces

a) A NEXCOM/NIMS interface **shall** be at the GNIs with the NIMS agent.

b) A NEXCOM/NIMS interface **shall** be at the A/G Router with a NIMS agent.

c) The NEXCOM/NIMS interface **shall** provide authentication of the information between NEXCOM and NIMS. [RD 7.3]

d) The NEXCOM/NIMS interface **shall** provide integrity assurance of the information between NEXCOM and NIMS. [RD 7.3]

e) The NIMS proxy agent for the RIUs, MDRs and UHF radios **shall** be located at the GNI.

3.2.4.3 Service/System/Subsystem Certification Requirements

a) The NEXCOM System **shall** provide remote monitoring information with sufficient accuracy to verify the correct configuration and operation of each subsystem. [RD 5.1.3; FAA-E-2911 Section 3.2.1.1b; 6000.15C, Chapter 5]

b) The NEXCOM System **shall** provide remote monitoring information with sufficient accuracy to verify the correct configuration and operation of the A/G communications service. [RD 5.1.3; FAA-E-2911 Section 3.2.1.1b]

3.2.4.4 System Monitoring Requirements

3.2.4.4.1 Monitored Parameter Status

a) The system/subsystem level parameters to be monitored **shall** include the following:

1. Mode of Operation (i.e., 25 kHz DSB-AM, VDL Mode 3, or 8.33 kHz DSB-AM)
2. Ground System Configuration (e.g., Diversity site group operation, VDL Mode 3 System Configuration)

3. RF Link Status [RD 3.3.3; RTCA/DO-224A, 2.4.2]
4. Telecommunications Status [RD 3.1.7.1, 3.2.4; SRD 3.2.4.6.2]
5. Subsystem/LRU Status (e.g., Up/Down status for Main/Standby/BUEC elements) [RD 3.1.7]
6. Data Subnetwork Status
7. Timing Source Status
8. Operational status of each Talk Group (e.g., PTT asserted, Main or Standby Tx and/or Rx selection, etc.)

Note: RF Link Status is intended to determine the RF performance of the system to isolate RF performance issues for interference isolation and to help isolate faults within the Radio systems and for trend analysis.

3.2.4.4.1.1 Performance Status Monitoring

a) The NEXCOM System **shall** collect and present the workload of systems resources. [FAA-E-2911, 3.2.1.2.3.a; FAA Order 6000.4]

Note 1: The workload is a measurement of the amount of work that a system processed in a specified time period (e.g., voice channel utilization).

b) The NEXCOM System **shall** collect and present the throughput of system resources. [FAA-E-2911, 3.2.1.2.3.b; FAA Order 6000.4]

Note 2: The throughput is a measurement of the amount of information that has passed through the system from input to output.

c) The NEXCOM System **shall** collect and present the response time of system resources. [FAA-E-2911, 3.2.1.2.3; FAA Order 6000.4]

Note 3: The response time is a measurement of the elapsed time for an information item from the time that it has entered into the system to the time that it has completed the process and moved out of the system.

3.2.4.4.2 Alerting/Alarming

a) System alarms/alerts **shall** be sent automatically to: [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e]

1. The local MMC interface
2. The remote MMC interface in accordance with 3.2.4 a)

Note: Alarms indicate when the system is performing external to the normal and alert ranges. An alert is indicated when the unit either changes configuration, or the unit is within the alert range.

b) A system alarm/alert **shall** automatically trigger the alarm/alert indicator on the front panel of the associated NEXCOM Subsystems. [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e]

c) NEXCOM Subsystems **shall** forward any alert/alarm received from a remotely monitored NEXCOM Subsystem according to the NEXCOM MMC System Hierarchy discussed in section 3.2.4.a). [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e]

3.2.4.4.3 MMC Data Logging

a) The NEXCOM System **shall** log the following: [FAA-E-2911, 3.2.1a through 3.2.1e]

1. Alerts
2. Alarms
3. All changes to system configuration and parameter values along with the unique identifier of the individual making the change
4. All control access attempts and the unique identifier of the individual making the attempt

Note: The Subsystem data logging will be captured in lower level documentation (e.g., SSS).

b) The NEXCOM System **shall** provide for archiving of log data. [RD 5.1.3; FAA-E-2911, 3.2.1a through 3.2.1e]

c) The NEXCOM System **shall** time stamp the data log with the time the information was generated by the originating subsystem. [RD 5.1.3; FAA-E-2911, 3.2.1a through 3.2.1e]

d) The NEXCOM System **shall** protect logs against unauthorized deletion and modification, even by system security administrators.

e) The NEXCOM System **shall** support centralized security incident reporting.

3.2.4.5 System Control Requirements

a) The NEXCOM System **shall** have control functions that allow authorized personnel to adjust designated parameters or exercise designated operational controls for specific subsystems(e.g., Frequency Tuning, VDL Mode 3 System Configuration, and Diversity Site Configuration). [RD 5.1.3]

b) The NEXCOM System **shall** terminate control access to any subsystem after a configurable amount of control inactivity.

Note: This requirement provides a level of security to the MMC functions.

3.2.4.6 Fault Isolation Requirements

3.2.4.6.1 Diagnostics and Fault Detection

a) The NEXCOM System **shall** include built-in tests and diagnostic functions to detect equipment failures and isolate equipment faults to the LRU level. [RD 5.1.3]

b) Diagnostic results and equipment faults **shall** be available via the local and remote MMC interfaces. [RD 5.1.3]

c) The NEXCOM System **shall** provide recovery features providing a measurement of survivability in the face of system failures and insecurities.

d) At startup, the NEXCOM System **shall** perform a self-check for the presence and correct operating capability of the security functions.

e) If the self-check of the security functions fails, the NEXCOM System **shall** generate an alarm.

f) The NEXCOM System **shall** start only if the self-check of the security functions pass.

g) If the self-check of the security functions passes, the NEXCOM System **shall** perform all operations in the secured state (based on the passing of the self-check).

3.2.4.6.2 Telecommunications Monitoring

a) The NEXCOM Subsystems that interface with telecommunications functions **shall** detect telecommunications (except MDRs analog interface) link failure. [RD 5.1.3; FAA-E-2885]

b) Upon loss of Telecommunications service for a site/channel, the affected site/channel **shall** inhibit its RF transmissions automatically. [RD 5.1.3; FAA-E-2885]

Note: For sites with redundant telecommunications, all lines for the channel must fail for the RF to be inhibited.

3.2.4.6.3 LRU Addressability

a) Every NEXCOM MMC capable LRU **shall** be uniquely addressable.

Note: NEXCOM MMC-capable LRUs are the LRUs that are accessible by the NEXCOM MMC capability, such as GNI, RIU and MDR.

3.2.4.7 Loss of Input Power

3.2.4.7.1 Momentary Interruption Impact

a) The system/subsystem operation **shall** not be affected by momentary interruptions.

3.2.4.7.2 Power Failure Recovery

a) After a power failure the subsystem **shall** verify proper operation, and resume operation, if possible.

3.2.4.8 Equipment Hot Swapping

a) The NEXCOM System **shall** support removal and replacement of LRUs without requiring the NEXCOM Subsystems to be power-down.

3.2.4.9 General Data Interfaces

a) The NEXCOM System **shall** provide at least three general purpose data interfaces for external devices to communicate between the control and radio sites. [FAA-E-2885]

b) These general data interfaces **shall** have a lower priority than voice, data, or control information.

3.2.5 Upgradability Functional Requirements

3.2.5.1 System Growth Margin

3.2.5.1.1 I/O Utilization

a) The NEXCOM System **shall** support general purpose discrete Inputs and Outputs (I/Os).

Note: These discrete I/Os are varying types (e.g., Analog, digital, contact closure).

b) The NEXCOM System **shall** allow for selectable monitoring of discrete I/Os.

c) When discrete item monitoring is selected/enabled, the NEXCOM System **shall** generate a user defined MMC message based on I/O state change.

d) The NEXCOM System discrete I/Os **shall** be mappable so that an input at a control site can generate at least one corresponding output at a remote site.

e) The NEXCOM System discrete I/Os **shall** be mappable so that an input at a remote site can generate at least one corresponding output at a control site.

f) The NEXCOM System discrete outputs **shall** be mappable to alert/alarm messages generated within the NEXCOM System (e.g., Telecommunications link failure status generating a discrete output).

3.2.5.1.1.1 Unused Interfaces

a) LRUs **shall** have spare I/O pins available for future expansion as subsystem requirements specify. [RD 3.2.14]

3.2.5.1.2 Vocoder

a) The vocoder function **shall** be upgradeable with additional algorithms. [DO 224A, 3.3.5.2.1, pg. 194]

Note: Vocoder upgrade may involve software changes, or both hardware and software changes. In the case of a hardware upgrade, the changes may include replacement of vocoder chips with newer version chips having compatible pin-out.

3.2.5.2 Software

a) The NEXCOM System **shall** be upgradeable with new software. [RD Att. 2]

3.2.5.2.1 Software Upgrade

a) An MMC function **shall** be provided to upgrade software by uploading new versions of application or operating system software in accordance with section 3.2.4 a). [RD 3.2.14, Att 2]

b) An MCC function **shall** be provided to delete any version of software or operating system software other than the software in operation.

3.2.5.2.2 Software Version Selection

a) An MMC function **shall** be provided that allows the selection of different versions of installed software, should more than one version be present.

3.2.5.2.3 Software Version Switch Failure Reversion

a) Upon failure of switching to a new software version, the device **shall** revert to the previous version of software.

3.2.5.2.4 Software Upload Authentication

a) The NEXCOM System **shall** provide authentication for all software uploads.

b) The NEXCOM System **shall** provide integrity assurance for all software uploads.

c) Software upload attempts **shall** be reported as system alarms to the MMC system for the following modes:

1. Authentication failure
2. Data Integrity failure
3. Successful uploads

d) When software upload failure is detected, the NEXCOM System **shall** reinitiate software upload only upon receiving a new upload command.

e) When software upload failure is detected, the NEXCOM System **shall** delete the failed upload from memory.

3.2.6 System Timing Functional Requirements

The following timing requirements apply:

3.2.6.1 Common Time Conditioning

a) The NEXCOM System **shall** provide a Timing Source [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

b) The NEXCOM System **shall** derive system time from the NEXCOM Timing Source per section 3.3.6.1.1. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

Note: System time is applicable to the GNI, RIU and MDR per section 3.3.6.

c) The NEXCOM Timing Source **shall** accept conditioning from an external Timing Reference. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

3.2.6.2 Timing Distribution

a) The NEXCOM System **shall** allow multiple collocated RIUs to synchronize from a single Timing Source. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

Note: This is not to introduce a common point of failure to all the affected RIUs. Redundancy of the timing source may be required.

3.2.7 Reliability, Maintainability, and Availability Functional Requirements

3.2.7.1 Reliability

a) The NEXCOM System **shall** support critical services per NAS-SR-1000.

3.2.7.1.1 Single Point of Failure

a) No single failure within the NEXCOM System **shall** cause loss of User Group communications. [NAS-SR-1000, 3.8.1C]

Note: This is derived from NAS-SS-1000, Volume I, par. 3.2.4.1

3.2.7.2 Maintainability

a) The NEXCOM System **shall** support critical services per NAS-SR-1000.

3.2.7.3 Availability

a) The NEXCOM System **shall** support critical services per NAS-SR-1000.

3.2.8 Security Measures

a) The NEXCOM System **shall** provide alerts upon the occurrence of security related events, including attempts to login, attempts of file transfer, and data file modifications.

Note: This requirement may duplicate other requirements in this document.

b) The NEXCOM System **shall** detect malicious code and data (e.g., viruses and worms).

c) The NEXCOM System **shall** provide a means to remove detected malicious code and data (e.g., viruses and worms).

d) The NEXCOM System **shall** support the maintenance of detection and removal functions.

e) The NEXCOM System **shall** support Virtual Private Network (VPNs) Technology (e.g., Internet Protocol Security (IPSEC) and VPNs) to communicate with external systems or via external telecommunications links. [NAS ISS Architecture]

f) The NEXCOM System **shall** generate alerts when file integrity is compromised.

g) The NEXCOM System **shall** implement screening/firewall/proxy server functionality, as appropriate to meet security requirements.

3.3 NEXCOM System Performance Requirements

a) The NEXCOM System **shall** meet or exceed the operational coverage area provided by the current analog voice system without degradation of service quality or increase of user workload beyond the workload of the current voice system.

3.3.1 Integration Within the NAS

The following subsections provide the requirements for integration of the NEXCOM System into the NAS.

3.3.1.1 Existing Facility

3.3.1.1.1 Power and Grounding

a) The NEXCOM System **shall** meet the power and grounding requirements of FAA-G-2100G. [RD 4.6.1]

3.3.1.1.1.1 Lightning Protection

a) The NEXCOM System **shall** provide lightning and transient protection, and harmonic suppression consistent with ANSI/IEEE Standards C62.36-1994, ANSI/IEEE Standards C62.41-1991, ANSI/IEEE Standards 519-1992, and ANSI/IEEE Standards C62.31-1987, for the following interfaces [RD 4.6.1]:

1. Power
2. Telecommunications
3. Antenna

3.3.1.1.2 Physical Requirements

The following requirements apply to all NEXCOM Subsystems unless otherwise noted.

3.3.1.1.2.1 Size

a) Each NEXCOM System Lowest Replaceable Unit (LRU) **shall** be 19" rack-mountable. [RD 4.2.2]

b) Each NEXCOM LRU **shall** be no more than 18 inches in depth, including connectors.

Note: Some NEXCOM Subsystems may be restricted in their allowable depth, which will be identified in the applicable SSS.

3.3.1.1.3 Cable Requirements

a) All NEXCOM cables **shall** meet the performance requirements specified in the following [RD 4.7]:

1. NFPA Standard 70, National Electrical Code
2. FAA Order 6630.4A, En Route Communications Installation Standards Handbook, Chapter 6, Section 3
3. FAA-C-1217F

3.3.1.1.4 Environmental and Energy Requirements

The following environmental and energy requirements apply to the NEXCOM System.

3.3.1.1.4.1 Pollution Control Requirements

a) The NEXCOM System **shall** meet the pollution control requirements specified in Executive Order 12088, *Federal Compliance with Pollution Control Standards*. [RD 4.3.1]

b) The NEXCOM System **shall** meet the pollution control requirements specified in Executive Order 13101, *Greening the Government through Waste Prevention, Recycling, and Federal Acquisition*. [RD 4.3.1]

c) The NEXCOM System **shall** meet the pollution control requirements specified in Executive Order 12873, *Federal Acquisition, Recycling, and Waste Prevention*. [RD 4.3.1]

d) The NEXCOM System **shall** minimize the generation of hazardous wastes as defined in 40 CFR 261, *Identification and Listing of Hazardous Wastes*. [RD 4.3.1]

3.3.1.1.4.2 Energy Conservation Requirements

a) The NEXCOM System **shall** meet the energy conservation requirements specified in Executive Order 13123, *Greening the Government Through Efficient Energy Management.* [RD 4.3.1]

b) The NEXCOM System **shall** meet the requirements of Executive Order 12902, *Energy Efficiency and Conservation at Federal Facilities*. [RD 4.4.1]

3.3.1.1.5 Safety Requirements

The following safety requirements apply to the NEXCOM System:

3.3.1.1.5.1 Electrical Safety Requirements

a) The NEXCOM System **shall** meet the personnel safety requirements specified in FAA-G-2100G, paragraphs 3.1, 3.2, and 3.3. [RD 6.2.1 (tailored)]

b) Facility electrical modifications to support the NEXCOM System **shall** comply with the requirements of NFPA 70. [NFPA 70]

3.3.1.1.5.2 Hazardous Materials

a) The NEXCOM System **shall** be free of asbestos, polychlorinated biphenyls (PCBs), lead, and class 1 ozone depleting substances. [RD 4.8.2]

b) The NEXCOM System **shall** limit personnel exposure to hazardous materials to the levels permitted by 29 CFR 1910 Subpart Z. [29 CFR 1910, Subpart Z]

3.3.1.1.5.3 Personnel Safety Requirements

a) The NEXCOM System **shall** comply with the requirements of 29CFR Parts 1910 and 1926. [RD 6.2.3]

b) The NEXCOM System **shall** comply with FAA Order 3900.19B, chapter 1, paragraphs 7e and 7*l*. [RD 6.2.2]

3.3.1.1.5.4 Seismic Safety

a) New construction supporting the NEXCOM System **shall** be in accordance with 49 CFR Part 41. [DOT implementation of EO 12699] [3.8.4.4.1.2]

b) The NEXCOM System elements installed in existing facilities **shall** be in accordance with FEMA-74. [DOT-SS-98-01 - DOT policy for EO 12941]

3.3.1.1.5.5 Equipment Safety

a) Connecting cables consistent with proper operation to or disconnecting cables from equipment in the NEXCOM System while the equipment is powered and the system is in operation **shall** not cause damage to any equipment in the NEXCOM System.

3.3.1.2 Coexistence

3.3.1.2.1 Radio Frequency Interference and Electromagnetic Interference

a) The NEXCOM System **shall** meet the RFI/EMI requirements specified in FAA-G-2100G, section 3.3.2.

3.3.2 Modes of Operation

3.3.2.1 VDL Mode 3 Standardization

a) The NEXCOM System **shall** meet the VDL Mode 3 performance requirements for ground systems specified in RTCA DO-224A.

b) The NEXCOM System **shall** meet United States regulatory performance requirements specified in FCC, NTIA, etc..

c) When there are conflicts between a) and b) above, the more stringent requirement **shall** take precedence.

3.3.2.2 25 kHz DSB-AM Standardization

a) The NEXCOM System **shall** meet the 25 kHz DSB-AM performance requirements specified in FAA-P-2883 and FAA-P-2884.

3.3.2.3 8.33 kHz DSB-AM Standardization

a) The NEXCOM System **shall** meet the 8.33 kHz DSB-AM performance requirements specified in ICAO Annex 10 and ETSI EN-300-676.

3.3.3 User Group Communications

3.3.3.1 Voice Communications Requirements

The following subsections provide the voice communications requirements for the NEXCOM System.

3.3.3.1.1 Voice Channels

a) The NEXCOM System **shall** support a control facility with at least [350] voice channels per control facility.

Note: Many control facilities will not have [350] voice channel capacity, therefore a scalable system has been required in 3.4.3.1.3 b).

3.3.3.1.2 Voice Quality/Intelligibility

a) The NEXCOM System **shall** not degrade the voice quality/intelligibility in a statistically inconsistent fashion from the current DSB-AM mode.

3.3.3.1.2.1 Audio Clipping

a) During normal operation, the NEXCOM System **shall** not truncate the voice signal received or transmitted.

b) During voice preemption operation and the channel is busy, the NEXCOM System **shall** allow truncation of the voice signal received and transmitted.

Note: This truncation refers to the nulling of the signal especially at the front end of a transmission.

3.3.3.1.3 Audio Throughput Delay

The audio throughput delay is defined as the time it takes for audio to transit through the NEXCOM System when the audio path has already been established, excluding the ground telecommunications circuits.

3.3.3.1.3.1 Uplink Path

a) The uplink audio throughput delay **shall** be no greater than 145 milliseconds in analog voice mode. [RD 3.2.7.1]

Note 1: This requirement pertains to DSB-AM operation through GNI/RIU/MDR equipment. Sustainment delays will be significantly less.

b) The uplink audio throughput delay **shall** be no greater than 173 milliseconds in digital voice mode. [RD 3.2.7.1]

Note 2: A –12 ms adjustment is made to the total budget due to the fact that vocoder frame 1 is to be modulated 12 ms prior to vocoder frame 6 in the MDR.

3.3.3.1.3.2 Downlink Path

a) The downlink audio throughput delay **shall** be no greater than 153 milliseconds in analog voice mode. [RD 3.2.7.1]

Note: This requirement pertains to DSB-AM operation through MDR/RIU/GNI equipment. Sustainment delays will be significantly less.

b) The downlink audio throughput delay **shall** be no greater than 61 milliseconds in digital voice mode. [RD 3.2.7.1]

3.3.3.2 Data Communications Requirements

The following requirements are only applicable when the NEXCOM System is operating with the VDL Mode 3 service.

The following defines the performance requirements based on Air Traffic Service Communication (ATSC) Classes of Service. If an application is defined to require a specified Class of Service, then the NEXCOM System is to support the performance indicated.

3.3.3.2.1 Data Service

3.3.3.2.1.1 Router Network Size

a) The NEXCOM System **shall** use between 2 and 48 A/G Routers.

3.3.3.2.1.2 Minimization of ATN Port Usage

a) The NEXCOM System **shall** provide a data switching function (See Appendix B.3.3) to concentrate GNI connectivity to a limited number of A/G Router ports.

3.3.3.2.1.3 Subnetwork Integrity

a) The NEXCOM subnetwork **shall** guarantee a probability of undetected packet error of less than 10^{-9}. [ICAO Doc 9705]

3.3.3.2.1.4 Subnetwork Transit Delay

a) The NEXCOM System **shall** successfully communicate 95% of the packets from one end of the subnetwork to the other based on the required class of service per the following table. [ICAO Doc 9705, Table 5.2-2]

Note: The requirement will mean that full prioritization will have to be supported by an efficient scheduler.

ATSC Class	Max Subnet 1-way delay 95% (sec)
A	Reserved
B	3.0
C	5.7
D	10
E	14.5
F	23.5
G	46.5
H	96.5

Table 3-1 Class and Delay.

3.3.3.2.1.4.1 Traffic Loading

a) The NEXCOM System **shall** support the traffic identified in Table 3-2 at the specified performance level.

Note 1: Either this traffic load needs to be run through an A/G Router without the overhead indicated in Note 2 of the Table, or the loading needs to be doubled to approximate the overhead associated with the router. [FAA Data Link Operational Requirements Team (DLORT)]
Note 2: For exponential interarrival traffic, a peaking factor of 3 is to be used. This peak traffic will be sustained for a period of 30 seconds. For deterministic traffic, no peaking factor is to be used due to the nature of the traffic.
Note 3: Table 3-2 is a representative estimate of the future loading of the system based on FAA Data Link Operational Requirements Team studies that is to be used to determine if the system provides sufficient performance. In reality, the traffic loading over time will likely be different. Some modifications were made to transfer some communications to broadcast medium to more efficiently utilize the capacity available.

Message Distribution	Priority	Uplink		Downlink	
		average message rate in steady state	average message size in bits	average message rate in steady state	average message size in bits
Exponential inter-arrival with Poisson message size	High	0.017	137	0.024	110
	Medium	0.0017	198	0.0008	100
	Low	0.001	2400	0.002	2400
Constant (Notes 5 & 6)	Low	0.017	3325	0.0033	1760

Notes: 1. Rates are in number of messages per second per aircraft
2. 31 octets of protocol header are added to each message in simulation
3. Each message is acknowledged at Data Link Sublayer except broadcast
4. Ack of uplink message uses downlink M subchannels, ack of downlink message requires 8 octet conveyed in the V/D (data) subchannels
5. Broadcast service is provided for constant uplink messages
6. Periodical fixed size downlink meteorological observations
7. All traffic collectively represents a Load Factor of 1

Ref: A Proposed VDLT Traffic Model for Capacity Simulation, AMCP/WG-D/5 WP-16, 1996

Table 3-2 Data Traffic Model

3.3.3.3 Continuous Broadcast

a) The NEXCOM System **shall** operate at up to 100 percent duty cycle in DSB-AM.

b) The NEXCOM System **shall** operate at up to 79.5 percent duty cycle in VDL Mode 3.

3.3.3.4 Connectivity

3.3.3.4.1 RESERVED

3.3.3.4.2 RESERVED

3.3.3.4.3 Subnetwork Leave Event Issuance Delay

a) The NEXCOM System **shall** issue Leave Events to the A/G Router based on the required class of service per the following table 95% of the time, measured from when the connection is lost to when the Leave Event is sent to the A/G Router. Different performance is specified depending on whether or not data traffic is present. [ICAO Doc 9705, Table 5.2-2]

ATSC Class	Max Delay Leave Event Issuance in Absence of Network Protocol Data Unit (NPDU)traffic 95% (sec)	Max Delay Leave Event Issuance in Presence of NPDU traffic 95% (sec)
A	Reserved	reserved
B	27	18
C	44	29
D	81	54
E	108	72
F	162	108
G	300	240
H	> 300	> 240

Table 3-3 Delay with and without NPDU

3.3.3.5 Ground Station Operations

a) The NEXCOM System **shall** support up to four User Groups on the same VDL Mode 3 frequency assignment.

b) Each NEXCOM Talk Group's voice communications resources **shall** be controllable independent from all other Talk Groups' voice communications resources.

c) The NEXCOM System **shall** support operation of multiple ground sites for one User Group in a sector having two to twelve diversely located RCFs.

Note 1: All sites are operating on the same frequency assignment and all using the time slot(s) assigned to the User Group. This includes both voice and data resources depending on the configuration in effect for VDL Mode 3 at the time.
Note 2: The operational configuration stated above refers to the Diversity Site Group operation.
Note 3: In this operation, each site may have unique airspace coverage relative to all other sites but will also have coverage in common with 1 or more other sites.

d) The NEXCOM System **shall** provide uplink M Beacons to all aircraft within a service volume to maintain timing state TS1 as defined in DO-224A.

Note 4: A 5.76 second interval allows for the worst-case situation where a particular site ceases beacon transmission. Aircraft radios may delay searching for new beacons for up to 5.76 seconds, thus at least one beacon pair from an alternate site will be available before an aircraft radio enters TS2 (approximately 12 seconds after losing the primary beacon signal). This note is based on voice only operation. For data operation see Note 1 above.

3.3.3.6 NEXCOM System Signaling Performance

In this section the NEXCOM System performance requirements are specified. Performance is generally expressed as latency, i.e., transit time through the NEXCOM. Telecommunications delays are explicitly **not** included in the delay times.

3.3.3.6.1 Push-to-Talk Transmitter Keying

a) For VDL Mode 3 mode and DSB-AM modes of operation using the PCM interface, the NEXCOM System **shall** transmit/cease transmit voice audio within 175 ms of the arrival of the PTT/PTT Release signal at the NEXCOM/VSCE interface for 99.9% if the events. [RD 3.2.7.1;FAA-e-2885, 3.2.3.2.2.1]

b) For DSB-AM modes of operation using an analog audio interface, the NEXCOM System **shall** transmit/cease transmit RF to 90% output power within 175 ms of the arrival of the PTT/PTT Release signal at the NEXCOM/VSCE interface for 99.9% of the events. [RD 3.2.7.1, 10.2.1.1; FAA-e-2885, 3.2.3.2.2.1]

Note 1: The above requirement may have to be wavered for certain transitional architectures, such as where FAATSAT and ANICS are used today.

c) In DSB-AM modes of UHF radio operation using the analog audio interface, the NEXCOM System **shall** indicate to the NEXCOM/VSCE interface the confirmation of PTT activation by the transmitter within 350 ms for 99.9% of the PTT confirmation events. [RD 10.2.1.1; FAA-E-2885, 3.2.3.2.2.1.1]

d) The NEXCOM System **shall** indicate to the NEXCOM/VSCE interface the confirmation of audio transmission within 350 ms for 99.9% of the PTT confirmation events. [RD 10.2.1.1; FAA-E-2885, 3.2.3.2.2.1.1]

Note 2: The PTT Confirmation is a continuous indicator with an overall latency of up to 575 ms.

3.3.3.6.2 Preemption of Aircraft Voice Transmissions

a) The NEXCOM System **shall** initiate transmission of a voice preemption signal in the next two scheduled uplink M-burst opportunities for the associated primary and backup radio sites when the condition of simultaneous presence of a voice preemption control signal and a PTT occurs at the NEXCOM/VSCE interface.

Note 1: The voice preemption should be transmitted in the first available uplink M-burst for the primary and its associated backup radio sites, if possible.

b) When simultaneous presence of a voice preemption control signal and a PTT at the NEXCOM/VSCE interface occurs more than 50 ms prior to the next scheduled uplink M-burst for the selected pair of primary and backup radio sites, the voice preemption signal **shall** be transmitted in the uplink M-burst for 99.9% of the override events.

c) The transmission of the voice preemption **shall** continue on all scheduled uplink M-bursts for the duration of simultaneous presence of a preemption control signal and a PTT.

Note 2: For diversity site group operation, the scheduled uplink M-bursts will rotate around the various ground stations in the diversity site group to ensure all aircraft in the coverage area will receive the timing and information.

d) When configured for diversity site group operation and during an attempted preemption, the NEXCOM System **shall** disable current downlink transmissions with the next uplink M-burst opportunity.

Note 3: This requirement implies that the ground station will change whatever rotation of uplink M-bursts so that the ground station (pair) from which the aircraft currently is receiving timing will send the next uplink M-burst(s). It may be desirable that the next ground station (pair) be the ground station selected for voice transmission.

e) The NEXCOM System **shall** provide, back to the NEXCON/VSCE interface, confirmation of voice preemption activation within 350 ms of its transmission for 99.9% of the events.

Note 4: The timeliness of the voice preemption is considered on par with the PTT signal.
Note 5: The timeliness of the voice preemption indication is considered on par with the PTT confirmation.

3.3.3.6.3 Squelch Break

a) The NEXCOM System **shall** indicate to the NEXCOM/VSCE interface squelch breaks in the receiver within 125 ms for 99.9% of the squelch break indication events.

Note 1: Squelch break is a continuous indicator with an overall latency of up to 350 ms.
Note 2: The timeliness of the squelch break indication is considered on par with the Channel Busy signal, as some regions use this signal to route audio.

3.3.3.6.4 Received Audio Muting

a) The NEXCOM System **shall** provide receive path muting/unmuting within 105 ms for 99.9% of the muting/unmuting events. [FAA-E-2885, 3.2.3.2.2.3]

b) The NEXCOM System **shall** provide receive path muting/unmuting confirmation to the NEXCOM/VSCE interface within 350 ms for 99.9% of the receive path muting/unmuting confirmation events. [FAA-E-2885, 3.2.3.2.2.3.1]

3.3.3.6.4.1 Audio Attenuation and Attenuation Delay

a) The audio attenuation **shall** be configurable from of 0, 15, or 20 dB.

b) The audio attenuation delay **shall** be configurable in duration for up to 600 ms (0 to 600 ms in 10 ms increments).

3.3.3.6.5 Ground Radio Resource Selection and Switching

a) The NEXCOM System **shall** switch radio resources (e.g., Main/Standby Select/Deselect, or BUEC Select/Reset as necessary) within 100 ms of receipt of the signal from the NEXCOM/VSCE interface for 99.9% of the radio resource selection events. [FAA-E-2885, 3.2.3.2.2.2]

b) The NEXCOM System **shall** confirm radio resource selection (e.g., Main/Standby Select Confirmation or BUEC Ready) within at most 250 ms from the time of switching for 99.9% of the radio resource selection events. [FAA-E-2885, 3.2.3.2.2.2.1]

Note: The radio resource selection confirmation has an overall latency of up to 425 ms from generation to display at the controller.

3.3.3.6.5.1 RESERVED

3.3.3.6.5.2 Automatic Radio Switching

a) The NEXCOM System **shall** switch from the failed radio to the operational alternate radio and be ready to operate over the alternate radio within 30 ms after detection of the radio failure.

Note: This does not apply to legacy radios.

3.3.3.6.6 Channel Busy Signal Performance

The Channel Busy signal is an indicator to the controller that a channel is not available. It is an indicator that is a feedback to a controller action, and it is a factor in the operational suitability of the system. An overall latency of 300 ms appears suitable, of which 125 ms can be allocated to the NEXCOM System.

a) The NEXCOM latency for the channel busy indicator **shall** be at most 125 ms for 99.9% of the channel busy events.

b) The NEXCOM latency for the VHF/UHF Lockout indicator **shall** be at most 125 ms for 99.9% of the lockout events. [RD 3.1.6.1; SRD 3.2.4.2a]

3.3.3.7 Ground Stuck Microphone Correction

a) The Ground Stuck Microphone timeout **shall** be configurable up to 5 minutes. [RD 3.3.1, 3.3.2; DO 224A, 3.3.2.1.1.1]

3.3.3.8 Telecommunications Links Performance

The NEXCOM Telecommunications performance requirements are defined below:

3.3.3.8.1 Telecommunications Delay and Delay Variations

a) The NEXCOM System **shall** operate when the Telecommunications one-way delay is up to 600 ms.

Note 1: It is desirable to limit one-way transfer delay to a minimum and below 25 msec. There are, however, circumstances that longer-delay telecommunication links, e.g., satellite links, are the only viable alternatives. The worst-case delay scenario defined for the NEXCOM is for a double satellite hop link with a maximum transfer delay of 600 ms (as defined by ANICS).

b) The NEXCOM System **shall** operate with transfer delay variations.

Note 2: Variations may be due to line switching, packet path variations, or clock slips.
Note 3: The extent of the variation will be addressed in future documentation.

c) The NEXCOM System transfer delay **shall** be minimized based on the characteristics of the Telecommunications media.

Note 4: When excessive delay characteristics exist in the NEXCOM System, special operational conditions usually exist such as low-density airspace.

3.3.3.8.2 Telecommunications Restoration Performance

The following are performance requirements associated with telecommunications restoration:

a) The restoration time, defined to be the combined time to detect the link failure, to transfer operation to a backup link, and to restore operations, **shall** be 6 seconds or less. [NAS-SR-1000]

Note 1: The conditions for declaring link failure will be defined in the NEXCOM/ Telecommunications ICD.

b) For telecommunications service interruption of less than 1 second in duration, the NEXCOM System **shall** restore the communications service within 120 milliseconds after the condition that caused the service interruption is removed.

c) When a backup telecommunications link is available, the NEXCOM System **shall** restore operation from the primary telecommunications link to the backup telecommunications link in 3 seconds or less after detection of the primary telecommunications service failure.

Note 2: A telecommunications service failure is defined as a telecommunications service interruption of 3 seconds in duration.

d) The NEXCOM System **shall** switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the primary telecommunications link is restored, when the PTT is not asserted, without loss of data.

Note 3: The conditions for telecommunications service interruption will be defined in future documentation.

e) The NEXCOM System **shall** switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the PTT is de-asserted upon restoration of the primary telecommunications link, without loss of data.

3.3.3.8.2.1 Standby Telecommunications Restoration Performance

a) When a backup telecommunications link is available and the system is in the standby telecommunications backup configuration, the NEXCOM System **shall** restore operation from the primary telecommunications link to the backup telecommunications link in 1 second or less after detection of the primary telecommunications service failure.

Note 1: A telecommunications service failure is defined as a telecommunications service interruption of 1 second in duration.

b) When configured for standby telecommunications backup after the primary link has failed, the NEXCOM System **shall** switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the primary telecommunications link is restored, without loss of data.

3.3.4 Maintenance, Monitoring and Control (MMC) Performance Requirements

3.3.4.1 Maintenance Requirements

3.3.4.1.1 LRU Maintenance

a) Maintenance of individual LRUs **shall** meet the requirements specified in FAA-G-2100G, Section 3.1.2.

Note: LRU weight is to comply with Section { 3.3.2.2.2}.

3.3.4.1.2 Non-Interference MMC

a) The NEXCOM MMC function **shall** not degrade system performance. [FAA Order 6000.30C, Section 11e(4); FAA-E-2911, Section 3.2.1c]

b) The failure of the MMC function **shall** not degrade the NEXCOM System operation.

3.3.4.2 NIMS Interface

a) The NEXCOM System **shall** provide at least 8 privilege levels for access to the NEXCOM MMC. [SRD 3.2.4.2, 3.4.6.3.4]

3.3.4.3 RESERVED

3.3.4.4 System Monitoring Requirements

3.3.4.4.1 Monitored Parameter Status

a) All data provided in response to maintenance or monitoring inquiries **shall** be less than two seconds old on average at the time of response, with a maximum of 4 seconds. [RD 5.1.2; FAA-E-2911, 3.2.3b]

b) The response **shall** be sent within 2 seconds average, 4 seconds maximum, after receipt of the inquiry. The time is measured from the time the managed subsystem receives the last byte of the data request to the time that the managed subsystem transmits the first byte of the response. [RD 5.1.2; FAA-E-2911, 3.2.3c]

3.3.4.4.2 Alerting/Alarming

a) All data provided in alerts and alarms **shall** be less than two seconds old on average at the time of generation, with a maximum of 4 seconds. [RD 5.1.2; FAA-E-2911, 3.2.3b]

3.3.4.4.3 MMC Data Logging

a) The NEXCOM System **shall** have 30 days of storage capacity for data logging entries to support diagnostics, and configuration management, without archival. [FAA-E-2911, 3.2.1a through 3.2.1e].

b) New data **shall** over-write the oldest user unprotected data when the storage capacity is reached for non-archived data. [FAA-E-2911, 3.2.1a through 3.2.1e]

c) The NEXCOM System **shall** automatically archive log entries that are older than 25 days. [FAA-E-2911, 3.2.1.a through 3.2.1.e]

d) The NEXCOM System archival function **shall** not over-write existing log data.

3.3.4.5 System Control Requirements

a) The subsystem **shall** complete the task of executing a change of a MMC parameter command within 1-second average, 3 seconds maximum, after receiving the command. [RD 5.1.2; FAA-E-2911, 3.2.3d]

Note: The process time is measured from the time the managed subsystem receives the last byte of the control command to the time that the managed subsystem transmits the first byte of the response or acknowledgment.

3.3.4.5.1 Frequency Range

a) The NEXCOM System **shall** provide communications services in the range of 112 -137 MHz.

b) The NEXCOM System **shall** provide selectable lock out of the band from 112-117.975 MHz to prevent accidental tuning into the band prior to reallocation of portions of or the entire band for ATC use.

Note: It is anticipated that the NEXCOM System will operate initially on the 118 – 136.975 MHz assigned channels.

3.3.4.5.2 RF Power Output

a) The RF output power of the NEXCOM System **shall** be adjustable from 2 to 50 watts (33 dBm to 47 dBm).

Note: The RF power range applies to all NEXCOM System modes.

3.3.4.6 RESERVED

3.3.4.7 System Startup

a) The NEXCOM System **shall** be operational within 5 minutes of applying power to the system components (subsystems).

Note: In the process of applying power to the subsystems, the subsystems are powered in some (random) sequence. The 5 minute requirement is applicable from the instant power is applied to the last subsystem.

b) Each NEXCOM Subsystem **shall** be operational within 5 minutes of applying power.

3.3.4.8 RESERVED

3.3.4.9 General Data Interfaces

a) The NEXCOM System **shall** interface at up to 9,600 bps communications on each of the general data interfaces. [FAA-E-2885]

b) The NEXCOM System **shall** provide an aggregate rate of at least 1,200 bps for all of the general data interfaces.

Note 1: The current RCE provides 880 bps total aggregate rate.

c) The general data interfaces **shall** not degrade system performance.

Note 2: This requirement means that the RS-232 interfaces are considered pass through and are only multiplexed on the NEXCOM telecommunication links and do nothing for the NEXCOM System. The general data interfaces will not interface with the MMC.

3.3.5 Upgradability Performance Requirements

3.3.5.1 System Growth Margin

a) The system **will** be implemented with excess computational capacity such that the initial utilization of system for both voice and data resources does not exceed the levels in the following paragraphs. [RD 3.2.14]

3.3.5.1.1 Discrete I/O Utilization

a) The NEXCOM System **shall** provide an output state change within 500 ms of the state change at the input where 99.9% of the discrete I/Os state change event, and so configured.

3.3.5.1.1.1 Unused Interfaces

a) Internal and external interfaces, which are not required for operations, **shall** not degrade system operations or performance, regardless whether they are activated or deactivated, open or terminated.

Note 1: This requirement intends to cover all interfaces that are used for MMC, including equipment internal or external test points, headphone connectors for local audio monitoring, microphone/PTT interface for local audio injection, MDT interfaces.

b) Unused interfaces, which are deactivated from operational use, **shall** not degrade system operations or performance, regardless whether they are open or terminated.

Note 2: This requirement is for interfaces that are intended for operational support but are not currently selected for use. For example, either the analog voice interface or the digital interface between RIU and MDR is activated, depending upon system configuration, and the deactivated interface should not degrade system operations or performance, regardless whether it is terminated or not.

3.3.5.1.1.2 NEXCOM System Throughput

a) I/O throughput provided **shall** have room for future expansions. [RD 3.2.14]

b) The NEXCOM System **shall** operate with full occupancy of all voice and data slots. [RD 3.2.12.1]

3.3.5.2 Software

3.3.5.2.1 Memory

The following memory requirements apply to each of the NEXCOM Subsystems.

Note: These requirements include memory built into processor devices.

3.3.5.2.1.1 Random Access Memory

a) The subsystems, as initially implemented, **shall** utilize less than 50% of the total available RAM. [RD 3.2.14]

3.3.5.2.1.2 Non-Volatile Memory

a) The subsystems, as initially implemented, **shall** utilize less than 50% of the total available non-volatile memory. [RD 3.2.14]

3.3.5.2.2 Processor Utilization

a) The utilization of all programmable processors **shall** not exceed 50 % of the maximum capacity of the device(s) as initially implemented. [RD 3.2.14]

3.3.6 System Timing Performance Requirements

The following timing requirements apply:

3.3.6.1 Common Time Conditioning

3.3.6.1.1 Timing Accuracy

a) System time, maintained by the RIU, **shall** be maintained within ± 10 microseconds (μs) of the Timing Source. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

b) GNIs **shall** maintain system time to within ± 10 microseconds (μs) of the RIU. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

c) MDRs **shall** maintain system time to within ± 10 microseconds (μs) of the RIU. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

d) The Timing Source **shall** maintain timing within ± 3 microseconds (μs) of the Timing Reference.

Note: The system is budgeted to allow 1/2 symbol timing error (47.1 ms) between radio sites on the same frequency in the same coverage area (e.g., RCAG/BUEC, or diversity site groups).

3.3.6.2 Timing Drift

a) With the loss of external Timing Reference conditioning, the Timing Source **shall** maintain system timing for at least 30 days without degrading system operation due to timing. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]

Note: This equates to requiring the Timing Source to drift at a rate no greater than 0.0139 ms/hour (0.33ms/day) before timing boundaries are violated for a 200 nmi sector, or at 0.675 ms/hour (16.2 ms/day) for a 160 nmi sector. Three slot sectors have significantly more guard time that can be used for timing uncertainty. For example, a 240 nmi sector would need a drift rate of no greater than 6.36 ms/hour (152.7 ms/day) to maintain timing for 30 days.

3.3.6.3 Timing Standard

a) The Timing Source **shall** be aligned with UTC on 6 January 1980. [Manual on VDL Mode 3, Technical Specifications 5.5.2.1.5]

Note: The above requirement implies that leap seconds are not compensated for, as leap second adjustments would perturb the operation of the system. GPS is one system that is aligned with UTC on 6 January 1980. Any other absolute time source which is traceable to UTC without leap second adjustments is also suitable as an external Timing Reference for VDL Mode 3.

3.3.7 Reliability, Maintainability, and Availability Performance Requirements

3.3.7.1 Reliability

3.3.7.1.1 NEXCOM Mean Time Between Outages (MTBO)

a) The MTBO of the NEXCOM Subsystem at an RCAG **shall** be greater than or equal to 19,996 hours. [RD 3.2.2.2]

Note: This requirement provides a constraint on the allocation of MTBF to subsystem elements to meet the service availability. Further information on how this is used is contained in Appendix E.

3.3.7.2 Maintainability

3.3.7.2.1 NEXCOM Mean Time to Restore (MTTR)

a) The NEXCOM RCAG MTTR, as defined by FAA Order 6040.15C, par. 702f [TBR], **shall** be less than or equal to 0.5 hour. [RD 3.2.3.1]

Note 1: This is derived from NAS-SS-1000, Volume I, par. 3.2.2.3.
Note 2: MTTR is defined to start from the time the service personnel arrives at the site and specifically excludes travel time.
Note 3: The MTTR calculation assumes a single LRU failure and includes the time to isolate the failure to a specific LRU, replace it and return it to service.

3.3.7.2.2 Periodic Maintenance

a) The equipment **shall** require on-site periodic maintenance no more than once per year. [RD 3.2.5.1]

b) Periodic maintenance tasks **shall** require no more than one person to accomplish. [RD 3.2.5.2]

Note 1: This is derived from NAS-SS-1000, Volume 1, par. 3.2.3.2.

c) Time to complete periodic maintenance tasks **shall** be equal to or less than existing equipment and require no more than 12 staff hours per year in accordance with NAS-SS-1000, Volume I, par. 3.2.3.2. [RD 3.2.5.3]

Note 2: Requirement c) is derived from NAS-SS-1000, Volume I, par. 3.2.3.2.

3.3.7.3 Availability Requirements

3.3.7.3.1 Voice Service Availability

a) The NEXCOM voice service availability, as defined by FAA Order 6040.15, par. 702c, **shall** be 0.99999 or greater. [RD 3.2.4.1]

3.3.7.3.2 Data Service Availability

a) The NEXCOM data service availability, as defined by FAA Order 6040.15, par. 702c, **shall** be 0.99999 or greater. [NAS-SR-1000, 3.8.1C]

3.3.7.3.3 Equipment Availability

a) The NEXCOM System equipment **shall** have an inherent availability of .999975 or greater in accordance with NAS-SS-1000, Volume I, par. 3.2.4. [RD 3.2.4.2]

Note: This requirement implies that each subsystem must have an MTBF of at least 19,996 hours.

3.4 Subsystem Functional Allocations

The NEXCOM Subsystem functional requirements are described in the following subsections.

3.4.1 MDR Functional Requirements

The following functional requirements apply only to MDR transmitter and receiver subsystems.

3.4.1.1 MDR Sustainment Operation

a) The NEXCOM MDR subsystems **shall** meet the functional requirements specified in the following:

1. FAA-P-2883, Purchase Description, VHF/UHF Air/Ground Communications Receiver
2. FAA-P-2884, Purchase Description, VHF/UHF Air/Ground Communications Transmitter

3.4.1.2 MDR Subsystem Functions

a) MDR transmitter subsystems **shall** be capable of providing the functions listed in Table 3-4.

Functions
1. Physical Layer
a) Synchronization sequence generation
b) Gray code encoding
c) Differential encoding
d) Bit scrambling
e) Golay Forward Error Correction (FEC) encoding
f) RF Output Power Control
g) Channel tuning
h) Modulation
2. Built-in-Test [TBD]
3. Programmability
4. Local MMC

Table 3-4 MDR Transmitter Functions

b) The MDR receiver **shall** provide the functions listed in Table 3-5.

Functions
1. Physical Layer
a) Synchronization sequence detection
b) Gray code decoding
c) Differential decoding
d) Bit descrambling
e) Golay FEC decoding
f) Channel tuning
g) Demodulation
2. Other Functions in Receiver

a) Squelch windowing
b) Squelch timing enforcement
c) Voice header identification
3. Built-in-Test [TBD]
4. Programmability
5. Local MMC

Table 3-5 MDR Receiver Functions

3.4.1.3 MDR Subsystem Interfaces

a) The MDR Transmitter and Receiver units **shall** have the following interfaces:

1. MDR/RIU Pulse Code Modulation (PCM) voice interface
2. MDR/RIU digital interface
3. MDR/MDT interface
4. MDR/RCE interface
5. MDR/Antenna interface
6. MDR/MDR RF-to-RF interface

3.4.1.4 MDR Human Interfaces

a) Each MDR transmitter **shall** include an on/off power switch.

b) Each MDR transmitter **shall** include a front panel display of the frequency, equipment state, and mode of operation.

c) Each MDR receiver **shall** include an on/off power switch.

d) Each MDR receiver **shall** include a front panel display of the frequency, equipment state, and mode of operation.

3.4.1.5 MDR System Timing

a) The MDR **shall** derive all necessary VDL Mode 3 TDMA timing using the information received from the RIU.

3.4.1.6 MDR Reliability/Maintainability

a) The MDR **shall** support critical services per NAS-SR-1000.

3.4.2 RIU Functional Requirements

The following functions apply only to the RIU subsystem.

3.4.2.1 RIU Subsystem Functions

3.4.2.1.1 RIU Physical Layer Functions

a) The RIU **shall** encode and decode Reed-Solomon (72, 62) codewords for VDL Mode 3 data burst operation per RTCA DO-224A, Section 3.3.1.3.3.3. [SRD 3.2.1.3]

3.4.2.1.2 RIU Media Access Control (MAC) Functions

a) The RIU **shall** implement the ground portion of the VDL Mode 3 MAC sublayer for voice, data and management functions as defined in RTCA DO-224A section 3.3.2.1, except for requirements related to system configurations 3T, 3S and 2S1X. [SRD 3.2.1.3]

Note: System configurations 3T, 3S and 2S1X are accepted to simplify the initial implementation, yet provide them as an upgrade capability.

b) The RIU **shall** be upgradeable to support all other VDL Mode 3 system configurations.

3.4.2.1.3 RIU Subsystem Voice Operation

3.4.2.1.3.1 RIU Subsystem PCM Voice Operation

a) The RIU **shall** use Pulse Code Modulation (PCM) to communicate audio with the MDR transmitter and receiver for DSB-AM modes of operation.

Note: Refer to RIU/MDR ICD for PCM Voice format.

3.4.2.1.3.2 RIU Subsystem Vocoder Operation

a) The RIU **shall** vocode audio between the GNI and the DSB-AM transmitter and receiver.

Note 1: This capability supports UHF radios when the VHF service is supporting VDL Mode 3, as well as the rare case when the GNI-RIU is supporting DSB-AM service for both VHF and UHF.

b) The RIU **shall** support both normal voice and downlink truncated voice data rates. [SRD 3.2.1.3]

Note 2: This requirement is to ensure that the ground station can provide received truncated voice to the controller in cases where the aircraft comes into coverage in the middle of a voice transmission.

3.4.2.1.3.3 Simultaneous Downlink UHF/VHF Voice

The following applies only when vocoding at the GNI:

a) When the RIU is supporting DSB-AM modes of operation for VHF, the RIU **shall** conference/sum audio received from the selected and unmuted VHF and UHF receivers.

b) When downlink activity is present on both VHF and UHF Talk Groups, the RIU **shall** be configurable to communicate both audio conversations to the GNI.

The following only applies when the RIU is configured to send only VDL Mode 3 VHF voice or UHF voice at a single time:

c) If a downlink UHF voice reception begins while a downlink VDL Mode 3 voice reception is in progress, the RIU **shall** notify the GNI of the UHF reception and drop the UHF reception until the VDL Mode 3 downlink voice reception terminates.

d) If a downlink VHF VDL Mode 3 voice reception begins while a downlink UHF voice reception is in progress, the RIU **shall** send the aircraft ID associated with the VDL Mode 3 reception to the GNI and drop the VDL Mode 3 voice reception until the UHF downlink voice reception terminates.

3.4.2.1.4 RIU Subsystem Mode 3 Data Operation

a) For VDL Mode 3 data operation, the RIU **shall** schedule data access as per the Manual for the Implementation of VDL Mode 3, Section 4.9.

b) The RIU **shall** provide means whereby the maintenance personnel can prevent the use of the Main or Standby resources for data operation.

Note: This is so that the technicians can perform maintenance on a portion of the system without interrupting the operation of the system.

c) Upon enabling or disabling of the maintenance restriction of b), the RIU **shall** maintain data flow without interruption.

3.4.2.1.5 RIU Link Management Entity (LME) Functions

a) The RIU **shall** provide the following LME functions as defined in RTCA DO-224A, Section 3.3.2.3: [SRD 3.2.1.3]

1. Net Initialization
2. Net Entry
3. Link Maintenance (e.g., polling)
4. Link Release
5. Expedited Recovery

b) The RIU **shall** be upgradeable to support all system configurations.

3.4.2.1.6 RIU Subsystem Mode 3 DLS Functions

a) The RIU **shall** provide the DLS ACK processing and priority queuing functions as defined in RTCA DO-224A, Section 3.3.2.2. [SRD 3.2.1.3]

b) The RIU **shall** perform error detection and address identification (ID) on all DLS frames received from an MDR receiver as defined in RTCA DO-224A, Section 3.3.2.2.1. [SRD 3.2.1.3]

3.4.2.1.7 RIU Local Maintenance, Monitoring and Control

a) The RIU **shall** interface to a local Maintenance Data Terminal to allow local control of the RIU. [SRD 3.4.6.1]

b) The RIU **shall** allow the locally connected MDT to remotely control all attached MDRs and all attached UHF radios. [SRD 3.4.6]

c) The RIU **shall** only accept control commands from an authenticated MDT.

d) The RIU **shall** allow an MDT to access all RIUs at the facility from a common connection point.

e) The RIU **shall** allow monitoring of its User Group resources in the GNI and its backup sites from its MDT ports.

3.4.2.1.7.1 RIU Front Panel Control and Monitoring

a) The RIU **shall** provide front-panel access to limited MMC capabilities to include:

1. Local Audio provision with independent volume control and slot selection
2. Status and Configuration Display

3.4.2.1.8 RIU System Timing Source

a) The RIU **shall** provide timing to the MDR transmitters and receivers.

Note 1: This timing is to allow for intersite synchronization to prevent interslot interference.

b) The RIU **shall** provide timing to the GNI.

Note 2: This timing is to allow the GNI vocoders to track the VDL Mode 3 timing to minimize end-end voice delay.

c) The RIU **shall** report the status of the Timing Source to the MMC function.

3.4.2.1.9 RIU Telecommunications Monitoring

a) The RIU **shall** inhibit RF transmissions upon detection of the loss of telecommunications service. [SRD 3.2.4.5.2]

Note: For dual control operation, this requires the loss of both control site connections.

3.4.2.2 RIU Subsystem Interfaces

a) The RIU **shall** have the following interfaces:

1. RIU/Analog Radio interface
2. RIU/MDR PCM voice interface
3. RIU/MDR digital voice/data interface
4. RIU/MDT interface
5. RIU/Timing Source interface
6. RIU/Communication Link interface to GNI

3.4.2.2.1 RIU Analog Radio Voice Interfaces

a) The RIU **shall** interface with up to four channels of existing analog UHF radio equipment, including Main/Standby Transmitter/Receiver units. [FAA-P-2883; FAA-P-2884]

Note 1: This implies up to 8 UHF transmitters and 8 UHF receivers.

b) The RIU **shall** use the digital audio signal from the GNI to drive the audio input of the analog voice radios.

c) The RIU **shall** provide connections to each of the UHF radio's RMMC ports. [RD 5.1.2]

Note 2: This requirement is to be applicable to the new UHF radio being procured by the FAA in the 2003 time frame. The protocol is being specified in the ICD yet to be written.

3.4.2.2.2 RIU/MDR Digital Interfaces

a) An RIU **shall** support up to two MDR transmitters and two MDR receivers.

3.4.2.2.3 General Data Interfaces

a) The RIU **shall** provide at least three RS-232 serial communications interfaces for general data interfaces to external devices. [FAA-E-2885]

b) These general data streams **shall** have a lower priority than voice, data, or control information.

3.4.2.3 RIU Human Interfaces

a) The RIU **shall** include an on/off power switch. [RD 6.1.1; FAA Human Factors Design Guide]

b) The RIU **shall** include a front panel display for the status of frequency, system configuration, equipment state, and mode of operation of the RIU. [RD 6.1.1; FAA Human Factors Design Guide]

3.4.2.4 RIU Site Configuration

a) The RIU **shall** a configuration with a common RIU supporting the transmitters and receivers associated with a User Group.

b) To support separate transmitter and receiver sites, the RIU subsystem **shall** support a split-RIU configuration where RIU devices are located at each of the separated sites.

Note: The split-RIU configuration is envisioned to reduce telecommunications requirements and provide better information security to the system than the RIU/MDR link. It is recognized that some of the VDL Mode 3 protocol default parameters may have to be adjusted for this configuration to account for the increased delay while the RIUs are coordinating net entries and data transfers.

3.4.2.5 RIU/Telecommunications Interfaces

a) The RIU **shall** interface with at least a 56 kbps digital service via a DDC interface to access the remote GNI. [SRD 3.2.8.1]

b) The RIU **shall** interface with analog 4-wire VG-6 ground telecommunications circuits to access the remote GNI, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.8.1]

c) The RIU **shall** interface with analog 4-wire VG-8 ground telecommunications circuits to access the remote GNI, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.8.1]

d) The RIU **shall** support sufficient telecommunications interfaces to provide dual control over redundant telecommunications links.

Note: The telecommunications interfaces may be on dissimilar media.

e) When configured for standby telecommunications backup, the RIU **shall** detect transmission path failures (defined as an inability to communicate with an GNI for a 1 second period), switch to an alternate transmission path, and restore communications to the GNI. [FAA-E-2885, 3.2.2.4]

f) When configured for hot telecommunications backup with a GNI, the RIU **shall** continue to communicate with the GNI with no loss of data when one of the telecommunications interfaces is degraded or fails. [SRD 3.2.3.8.2.2]

3.4.2.6 RIU/GNI Interfaces

a) The RIU **shall** interface with up to two GNIs via RIU/Telecommunications interface(s). [SRD 3.2.3.6.7]

b) For dual control the RIU **shall** interface with two GNIs via RIU/Telecommunications interface(s) and/or direct connectivity. [SRD 3.2.3.6.7]

c) The RIU **shall** provide authentication of the information between the RIU and GNI. [RD 7.3]

d) The RIU **shall** provide integrity assurance of the information between the RIU and GNI. [RD 7.3]

3.4.2.7 Power Interfaces

a) The RIU **shall** interface with existing power in NAS facilities consistent with FAA Order 6950.2D. [SRD 3.2.2.1, 3.8.2.1]

3.4.2.8 Signaling

a) The RIU **shall** communicate the following signals with the GNI:

1. PTT/PTT Release [SRD 3.2.3.5]
2. Receiver Mute/Unmute [SRD 3.2.20]
3. Voice Preemption [RD3.3.1; SRD 3.2.6]
4. Main/Standby Radio Selection
5. BUEC Select/Reset

b) The RIU **shall** provide confirmation signals indicating successful completion of the following actions to the GNI:

1. PTT/PTT Release [SRD 3.2.3.5]
2. Receiver Mute/Unmute [SRD 3.2.20]
3. Squelch Break [SRD 3.2.16]
4. Main/Standby Selection [RD 3.1.1.4]
5. BUEC Select/Reset [RD 3.1.1.4]

c) The RIU **shall** mute the received audio of the UHF and/or VHF radios when so commanded. [SRD 3.2.20]

d) The RIU **shall** be configurable to either pass through a PTT /PTT Release Confirmation signal or generate the signal per f). [RD 3.1.7.1; SRD 3.2.3.5]

e) The RIU **shall** utilize the receiver to loop back the transmitted audio to determine the RIU-generated PTT/PTT Release Confirmation signal. [RD 3.1.7.1; SRD 3.2.3.5]

Note: This capability will not be available to all configurations of the NAS, as not all sites allow the receiver to hear the transmitter.

f) The RIU **shall** use the End of Message (EOM) bit or lack of voice messages to indicate squelch break inactive, while operating in VDL Mode 3 mode. [SRD 3.2.16]

g) The RIU **shall** use signaling information from the GNI to select the active MDR and UHF radio units. [FAA-E-2885; SRD 3.2.15]

h) When any PTT is activated, the RIU **shall** inhibit the main/standby (M/S) select function for that frequency (i.e., inhibit the re-routing of the voice and control signals and inhibit the switching of the antenna transfer relay). [SRD 3.2.15.1e]

i) When the RIU is operating in Dual Control mode and when another user overrides access at the RIU, the RIU **shall** pass VHF and UHF Lockout signals back to the GNI to indicate when access to the RIU is lost. [RD 3.1.6.1; SRD3.2.4.2a]

3.4.2.9 RIU Reliability/Maintainability

a) The RIU **shall** support critical services per NAS-SR-1000.

3.4.3 GNI Functional Requirements

The following functions apply only to GNI subsystems.

3.4.3.1 GNI Subsystem Functions

3.4.3.1.1 GNI/VSCE Interfaces

a) The GNI **shall** interface with existing VSCE (e.g., VSCS, ETVS, ICSS, RDVS, STVS) via existing interfaces (e.g., Single channel (V+U) and quad channel (V/U/M/S)). [FAA-E-2885]

b) The GNI **shall** interface with voice switches via a common digital interface.

Note: The intent is for this to be an interface common to all VSCE that will be defined in the ICD yet to be coordinated with the Voice Switching Group.

3.4.3.1.2 GNI/Telecommunications Interfaces

a) The GNI **shall** interface with at least a 56 kbps digital service via a DDC interface to access the remote RIU. [SRD 3.2.8.1]

b) The GNI **shall** interface with analog 4-wire VG-6 ground telecommunications circuits to access the remote RIU, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.8.1]

c) The GNI **shall** interface with analog 4-wire VG-8 telecommunications circuits to access the remote RIU, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.8.1]

d) The GNI **shall** support redundant telecommunications interfaces for each RIU per Section 3.2.3.8.1.e).

Note 1: The telecommunications interfaces may be on dissimilar media.

e) When configured for standby telecommunications backup, the GNI **shall** detect transmission path failures (defined as an inability to communicate with an RIU for a 3 second period), switch to an alternate transmission path, and restore communications to the RIU. [FAA-E-2885, 3.2.2.4]

Note 2: This assumes the presence of an alternate telecommunications path to the RIU. It is recognized that not all sites have this redundancy.

f) When configured for hot telecommunications backup with an RIU, the GNI **shall** simultaneously communicate over the redundant telecommunications interfaces with that RIU. [SRD 3.2.3.8.2.2]

g) When configured for hot telecommunications backup with an RIU, the GNI **shall** be able to use information from either interface without interfering with the operation of the communications system. [SRD 3.2.3.8.2.2]

h) When configured for standby telecommunications backup with an RIU, the GNI **shall** communicate over at least one telecommunications interface with that RIU. [FAA-E-2885, 3.2.2.4]

3.4.3.1.3 GNI/RIU Interfaces

a) The GNI **shall** interface with RIUs via the GNI/Telecommunications interface.

Note 1: This includes the capability for Local Radios, where RIUs will be required.

b) The GNI **shall** be scalable in the number of RIUs that may be supported.

c) The GNI **shall** provide authentication of the information between the GNI and RIU. [RD 7.3]

d) The GNI **shall** provide integrity assurance of the information between the GNI and RIU. [RD 7.3]

e) The GNI **shall** support a configuration with separate RIUs for transmitters and receivers.

Note 2: The separate RIUs are envisioned to be using different telecommunications interfaces, and the GNI will need to forward messages between the two RIUs.

3.4.3.1.4 GNI/Router Interfaces

a) A GNI **shall** interface with an A/G Router via a GNI Data Switch function, per Appendix B.4. [RD Att 2]

Note 1: GNIs may share the data switch function to interface with the A/G Router.

b) A GNI **shall** interface with at least two different A/G Routers. [SRD App E; RD Att 2]

Note 2: GNIs may share the data switch function to interface with the A/G Router.

3.4.3.1.5 GNI/GNI Interfaces

a) The GNI Data Switch function **shall** merge data communication paths from GNIs to an A/G Router. [SRD 3.2.1.3a]

b) The GNI Data Switch function **shall** be used to interconnect GNIs. [SRD 3.2.1.3a]

Note 1: Not every GNI is required to implement this Data Switch function. This function may be implemented in a separate LRU.

c) GNIs from adjacent control facilities **shall** coordinate handoffs of aircraft between these facilities. [SRD 3.2.1.3a]

Note 2: There are two types of aircraft data handoffs: one that is GNI/GNI connected to the same A/G Router port and one which is between A/G Router ports.

d) The GNI **shall** provide authentication of the information between GNIs. [RD 7.3]

e) The GNI **shall** provide integrity assurance of the information between GNIs. [RD 7.3]

f) The GNI **shall** support at least two paths for GNI interconnections. [SRD App E]

Note 3: This requirement is intended to provide diverse connections from a GNI up to diverse A/G Routers and the GNI interconnections. This may be implemented via redundant lines between GNIs or via connections to other GNIs to provide a diverse path.

3.4.3.1.6 GNI/Automation Interfaces

a) The GNI **shall** interface with the automation system to receive Next Channel Uplink information. [RD 6.1.2; SRD 3.2.1.3a]

b) The GNI **shall** receive confirmation from the radio site as to the success of the uplink of the Next Channel Uplink information. [SRD 3.2.1.3a]

c) The GNI **shall** present to the automation system the confirmation signal on success of the Next Channel Uplink transmission. [SRD 3.2.1.3a]

d) The GNI **shall** deliver Next Channel Uplink confirmations to the automation system. [SRD 3.2.1.3a]

e) The GNI **shall** provide indication to the automation system of the login status of aircraft. [SRD 3.2.1.3a]

f) The GNI **shall** provide indication to the automation system of the Talker ID (Aircraft ICAO Address) of the aircraft communicating on the voice channel for VDL Mode 3. [SRD 3.2.1.3a]

g) The GNI **shall** provide indication to the automation system of received Urgent Downlink Requests for VDL Mode 3. [SRD 3.2.1.3a]

3.4.3.1.7 GNI General Purpose Interfaces

a) The GNI **shall** provide at least 3 RS-232 data connections for use in general messaging with the remote site via the RIU.

b) The general data streams **shall** have a lower priority than voice, data, or control information.

3.4.3.1.8 GNI Man-Machine Interfaces

a) The GNI **shall** indicate the operational voice activity of each voice circuit.

Note 1: The indication may be presented to the front panel or MMC Workstation depending on human factors requirements.

b) The GNI **shall** indicate the status of each thread.

Note 2: The indication may be presented to the front panel or MMC Workstation depending on human factors requirements.

c) The GNI **shall** be configurable only from the NEXCOM/NIMS interface and the MMC Workstation. [SRD 3.4.6]

3.4.3.1.9 Power Interfaces

a) The GNI **shall** interface with existing critical power in NAS facilities consistent with FAA Order 6950.2D. [SRD 3.2.2.2, 3.8.2.1]

b) The GNI **shall** comply with requirements of the critical power bus. [SRD 3.2.2.2]

c) The GNI **shall** continue to operate at least twenty minutes after the loss of critical power. [Potential NCPs on RCE]

Note: Further consideration of this requirement is ongoing.

3.4.3.2 GNI Subsystem Communication Functions

3.4.3.2.1 Air/Ground Voice and Data

a) The GNI **shall** multiplex voice and data for transmission to the appropriate ground station RIU.

3.4.3.2.2 Signaling

a) The GNI **shall** pass the signaling indicated in Section 3.4.2.8 b), h) and j) from the VSCE to the RIU: [RD 3.4.1; FAA-E-2885]

b) The GNI **shall** return confirmations of successful action completion from the RIU to the VSCE as indicated in Section 3.4.2.8 d). [RD 3.4.1; FAA-E-2885]

c) The GNI **shall** pass the signaling from the RIU to the VSCE as indicated in Section 3.4.2.8 b), f), j), and l). [FAA-E-2885]

Note: The Automation interface may introduce additional signaling to support its functions.

3.4.3.3 GNI Subsystem Voice Operation

When supporting voice operations, the following apply:

a) The GNI **shall** compress/decompress speech using the vocoder specified in ICAO Annex 10, Vol. III, Part 1, Chapter 6 for each Talk Group. [RD 3.2.6.1, 5.4.1]

Note: A Talk Group is defined as the voice and data resources assigned to a controller team on a single Talk Group.

3.4.3.4 GNI Subsystem Data Operation

3.4.3.4.1 VDL Mode 3 Data Operation

a) The GNI **shall** provide VDL 8208 Packet Layer Protocol (PLP) compression, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3 and Appendix J. [RD 5.4.1; SRD 3.2.1.3a]

b) The GNI **shall** provide CLNP frame mode compression, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3, and Appendix K. [RD 5.4.1; SRD 3.2.1.3a]

c) The GNI **shall** provide raw subnetwork interface data transfer services for non-ATN messaging, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]

d) The GNI **shall** provide IEC/ISO 8208 data transfer services, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]

e) The GNI **shall** provide CLNP data transfer services, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]

f) The GNI **shall** be upgradeable to provide ATN Frame Mode subnetwork interface data transfer services, as requested by mobile users, as defined in Change 1 to RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]

g) The GNI **shall** provide MbB services as defined in RTCA/DO-224A, Section 3.3.3.3. [RD 5.4.1; SRD 3.2.1.3a]

Note 1: The GNI should minimize the transit delay associated with the handoff between A/G Routers. [SRD 3.3.5.1]
Note 2: The GNI should minimize the channel blockage associated with the handoff between A/G Routers. [SRD 3.3.5.1]
Note 3: Section 3.3.5.2 applies during handoffs as well to establish a maximum acceptable level.

h) The GNI group **shall** report to the A/G Router only those connectivity changes to the subnetwork that affect A/G Router connectivity decisions, as defined in RTCA/DO-224A, Section 3.3.2.3. [RD 5.4.1; SRD 3.2.1.3a]

Note 4: A GNI group is a collection of interconnected GNIs that interface to a single A/G Router port.

i) The GNI **shall** not permit any of its functions or components to be used to access unauthorized parts of the NAS external to the NEXCOM System. [RD Att 2]

3.4.3.5 GNI Subsystem Remote Maintenance, Monitoring and Control Functions

3.4.3.5.1 GNI Subsystem Remote Monitoring Functions

a) The GNI **shall** monitor the functional status of its associated RIUs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

b) The GNI **shall** monitor the functional status of its associated Timing Sources. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

c) The GNI **shall** monitor the functional status of its associated MDRs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

d) The GNI **shall** monitor the functional status of its associated UHF radios. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

e) The GNI **shall** support monitoring of the port status of its A/G Router(s). [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

3.4.3.5.2 GNI Subsystem Remote Control Functions

a) The GNI **shall** support remote control its associated RIUs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

b) The GNI **shall** support remote control its associated MDRs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

c) The GNI **shall** support remote control its associated UHF radios. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]

d) The GNI **shall** coordinate operation of primary and backup site radio strings for a given User Group.

Note: This includes coordination of the data protocol states between the sites and Beaconing control.

3.4.3.5.3 GNI/MMC Workstation Interface

a) Each GNI **shall** interface to the collocated MMC Workstation.

3.4.3.6 GNI Reliability/Maintainability

a) The GNI **shall** support critical services per NAS-SR-1000.

Note: This is based on the string, or thread, associated with the GNI and RIU.

3.4.3.6.1 GNI Redundancy

a) The failure of any thread(s) within the GNI to its RIU **shall** not degrade communications of any other GNI/RIU threads. [RD 3.2.1.2]

b) A failure within a GNI **shall** not cause loss of communications within a User Group. [RD 3.2.1.2, Appendix E]

c) Failure of a single GNI thread **shall** not cause loss of A/G communications Services. [RD 3.2.1.2]

3.4.4 A/G Router Functional Requirements

The A/G Routers within the NEXCOM and the ATN regional backbones make up the ATN Router subsystems.

Note: The references to ICAO Document 9705 refer to Edition 3 or later.

3.4.4.1 A/G Routing

a) The A/G Router **shall** implement air/ground routing protocols as per ICAO Document 9705. [SRD 3.2.17.2]

b) Each A/G Router **shall** be located at an ARTCC. [SRD 3.3.5]

Note: A/G Routers are being restricted to only be located at ARTCCs to reduce the capacity impact of IDRP connection changes through the narrow bandwidth of the A/G channel.

c) Each A/G Router **shall** be responsible for providing the ATN subnetwork services to the GNI(s) within its domain. [SRD 3.3.5]

d) The A/G Router **shall** conform to FAA routing policies.

3.4.4.1.1 A/G Router Subnetwork Services

The A/G Router provides and interfaces through the Subnetwork Dependent Convergence Function (SNDCF) to support VDL Mode 3 8208 Packet Layer Protocol (PLP Compression, Connectionless Network Protocol (CLNP) Frame Mode Compression, and ATN Frame Mode.

3.4.4.1.1.1 SNDCF for ISO/IEC 8208 Mobile Subnetworks

a) The A/G Router **shall** implement the SNDCF for ISO/IEC 8208 Mobile Subnetworks as per ICAO Document 9705, as an interface to the VDL Mode 3 8208 PLP Compressor. [SRD 3.2.1.3; ICAO Doc 9705]

3.4.4.1.1.2 SNDCF for Frame Mode Mobile Subnetworks

a) The A/G Router **shall** be upgradeable to implement the SNDCF for Frame Mode Mobile Subnetworks as per ICAO Document 9705, as an interface to the ATN Frame Mode Compressor. [SRD 3.2.1.3; ICAO Doc 9705]

Note: The ATN SARPs refers to this as Frame Mode, while the VDL Mode 3 SARPs and MASPS refer to this as ATN Frame Mode.

3.4.4.1.1.3 SNDCF for VDL Mode 3 Frame Mode Mobile Subnetworks

a) The A/G Router **shall** implement the SNDCF for VDL Mode 3 Frame Mode Mobile Subnetworks as per ICAO Document 9705, as an interface to CLNP Frame Mode Compressor. [SRD 3.2.1.3; ICAO Doc 9705]

3.4.4.2 Maintenance, Monitoring and Control

3.4.4.2.1 Local MMC

a) The A/G Router **shall** provide local configuration, monitoring and control for the router. [SRD 3.4.6.1]

3.4.4.2.2 Remote MMC

a) The A/G Router **shall** provide MMC access of the router to the NIMS. [SRD 3.4.6]

3.4.4.3 A/G Router Reliability/Maintainability

a) The A/G Router subsystem **shall** provide at least two independent paths from the GNI to the ATN network. [SRD 3.5.3.1, E.5]

Note: To meet a service availability of 0.99999 for critical service, there will need to be a second router path available to each GNI.

3.4.5 MDT Functional Requirements

a) The MDT **shall** provide a means for asserting the same operational functions normally available via the VSCE interface (e.g., Main, Standby, and BUEC transmitters and receivers PTT, Mute, etc.) for each Talk Group(s) to which it is attached.

b) The MDT **shall** provide a means for monitoring the operational status of the User Group(s) to which it is attached.

3.4.5.1 Local MMC

a) The NEXCOM MDT function **shall** use an existing NAS MDT to access local maintenance, monitoring and control functions of the RIU, and MDR. [SRD 3.4.6.1]

3.4.5.2 Remote MMC

a) When connected to an RIU, the NEXCOM MDT function **shall** access remote MMC information from all MDRs, and UHF radios that are attached to the RIU. [SRD 3.4.6]

Note: It is desirable when directly connecting a MDT to a RIU that one can plug into a single unit at the remote site and perform MMC on all components at the site without having to reconnect with each individual component.

3.4.5.3 Logging

a) The MDT **shall** download and store the log files from the RIUs, and MDRs at a site. [SRD 3.4.1.4]

3.4.5.4 MDT Security

a) The MDT **shall** support the assignment of a unique logon identifier for each user.

b) When passwords are to be used for authentication, the MDT **shall** use strong passwords (e.g., prevent the use of dictionary words).

c) The MDT **shall** enforce mandatory password changes at set intervals.

d) The MDT **shall** prevent the reuse of passwords on a per user basis.

e) The RIU/MDT **shall** implement strong authentication.

f) The MDT **shall** enable access authorization management; i.e., the initialization, assignment, and modification of access tights (e.g., read, write, execute) to MMC functions with respect to (1) group membership (privilege level); and (2) such constraints as port-of-entry.

g) The MDT shall enforce separation of duties through its role-based ability to restrict users to specific MMC functions and to specific actions on those functions.

Note 1: This requirement is based on privilege levels defined elsewhere in this document.

h) The MDT **shall** temporarily (a configurable period of time) suspend user accounts after a configurable number of consecutive failed logon attempts.

i) The MDT **shall** display a configurable banner page upon login.

j) The MDT **shall** protect NEXCOM information system security data from all unauthorized access.

Note 2: This may require encryption of log file and key material in addition to protecting security functions.

k) The MDT **shall** terminate control access to any subsystem after a configurable amount of control inactivity.

3.4.6 Workstation Functional Requirements

a) The MMCWS **shall** provide a means for asserting the same operational functions normally available via the VSCE interface (e.g., Main, Standby, and BUEC transmitters and receivers, PTT, Mute, etc.) for each Talk Group(s) to which it is attached.

b) The MMCWS **shall** provide a means for monitoring the operational status of the User Group(s) to which it is attached.

3.4.6.1 Local MMC

a) The MMCWS **shall** be a control access point for local maintenance, monitoring and control functions of the GNI. [SRD 3.4.6.1]

3.4.6.2 Remote MMC

a) The MMCWS **shall** access remote MMC information from all connected RIUs. [SRD 3.4.6.2]

b) The MMCWS **shall** access remote MMC information from all connected MDRs. [SRD 3.4.6.2]

c) The MMCWS **shall** access remote MMC information from all connected UHF radios. [SRD 3.4.6.2]

d) The MMCWS **shall** monitor all connected A/G Routers. [SRD 3.4.6.2]

Note 1: This would be via the NIMS connection to the GNI.

e) The MMCWS **shall** monitor MMC information from the Data Link Application End System responsible for the GNI with which the MMCWS is associated. [SRD 3.4.6.2]

Note 2: This is intended to be the ability to ping and trace route to the End System.
Note 3: The above is expected to be available through the NIMS interface of the Data Link Application End System. This End System is part of the automation system (e.g., DLAP).

3.4.6.3 Logging

a) The MMCWS **shall** log all alerts and alarms from all NEXCOM Subsystems. [SRD 3.4.1.4]

b) The MMCWS **shall** log all MMC control commands sent to the NEXCOM Subsystems, except the A/G Router. [SRD 3.4.1.4]

c) The MMCWS **shall** log all access attempts to the MMC system. [SRD 3.4.1.4]

3.4.6.4 Platform Requirements

a) The MMCWS **shall** reside on platforms compatible with those already in the NAS, to include MDT platforms.

Note: In case of catastrophic failure of the MMCWS, the MDT can function as the MMCWS for a short period of time. This also means that the interface between the GNI and MMCWS has to also exist on the MDT.

3.4.6.5 MMCWS Security

a) The MMCWS **shall** support the assignment of a unique logon identifier for each user.

b) The MMCWS **shall** authenticate the claimed user's identity before allowing the user to perform any actions other than a well-defined set of operations.

c) When passwords are to be used for authentication, the MMCWS **shall** use strong passwords (e.g., prevent the use of dictionary words).

d) The MMCWS **shall** enforce mandatory password changes at set intervals.

e) The MMCWS **shall** prevent the reuse of passwords on a per user basis.

f) The MMCWS **shall** implement strong authentication.

g) The MMCWS **shall** enable access authorization management; i.e., the initialization, assignment, and modification of access rights (e.g., read, write, execute) to MMC functions with respect to (1) group membership (privilege level); and (2) such constraints as port-of-entry.

h) The MMCWS **shall** enforce separation of duties through its role-based level to restrict users to specific MMC functions and to specific actions on those functions.

Note 1: This requirement is based on privilege levels defined elsewhere in this document.

i) The MMCWS **shall** provide resource allocation features having a measure of resistance to resource depletion (mitigate denial of service attacks).

j) The MMCWS **shall** temporarily (a configurable period of time) suspend user accounts after a configurable number of consecutive failed logon attempts.

k) The MMCWS **shall** display a configurable banner page upon login.

l) The MMCWS **shall** protect information system security data and functionality from all unauthorized access.

Note 2: This may require the encryption of log file and key material in addition to protecting security functions.

m) The MMCWS **shall** terminate NEXCOM control access to any subsystem after a configurable amount of NEXCOM control inactivity.

3.4.7 Timing Source

3.4.7.1 Time Conditioning

a) The Timing Source **shall** synchronize timing with the Timing Reference.

b) The Timing Source **shall** provide timing to connected RIU (s).

3.4.7.2 Timing Source Interfaces

a) The Timing Source **shall** interface with the Timing Reference.

b) The Timing Source **shall** interface to collocated RIU (s) [SRD 3.2.6.3.a]

3.4.7.3 Status Monitoring

a) The Timing Source **shall** monitor the status of the Timing Reference.

b) The Timing Source **shall** provide status information concerning the Timing Reference to the RIU.

3.5 Subsystem Performance Allocations

The following subsections provide the performance allocations for the NEXCOM MDR, RIU, GNI, A/G Router, MDT and MMC Workstation.

3.5.1 MDR Performance Allocations

The following performance requirements apply only to the MDR.

3.5.1.1 MDR Sustainment Operation

a) The NEXCOM MDR subsystems **shall** meet the performance requirements specified in the following:

1. FAA-P-2883, Purchase Description, VHF/UHF Air/Ground Communications Receiver
2. FAA-P-2884, Purchase Description, VHF/UHF Air/Ground Communications Transmitter

3.5.1.2 MDR Subsystem Functions

3.5.1.2.1 MDR Audio Processing Delay

Note: See Appendix F for further explanation regarding the audio delay.

3.5.1.2.2 Uplink Digital Voice Delay in MDR Transmitter

a) The uplink audio processing delay contribution of each MDR transmitter in digital voice modes **shall** be less than or equal to 6 ms, measured from the reception of the complete High-Level Data Link Control (HDLC) voice burst message containing vocoder frame 6 from the RIU to the time when the MDR begins RF transmission (referenced to the antenna port) of the first D8PSK symbol in vocoder frame 6. [SRD 3.3.4.2.1]

3.5.1.2.3 Uplink Analog Voice Delay in MDR Transmitter

a) The uplink audio processing delay contribution of each MDR transmitter in analog voice modes via the PCM voice interface to the RIU **shall** be less than or equal to 9 ms, measured from the reception of the second complete RIU HDLC PCM voice message to the time when the MDR begins RF transmission (referenced to the antenna port) of the first PCM voice message. [SRD 3.3.4.2.1]

b) In sustainment mode, the audio processing delay in the MDR transmitter, measured from the analog voice input port on the MDR transmitter to the transmitter antenna port, with the Push-to-Talk (PTT) signal line activated at the RCE/MDR interface, **shall** be less than 13 ms. [SRD 3.3.4.2.1]

3.5.1.2.4 Downlink Digital Voice Delay in MDR Receiver

a) The downlink audio processing delay contribution of the MDR receiver in digital voice modes **shall** be less than or equal to 17 ms, measured from the Time of Arrival of the last D8PSK symbol of the first vocoder frame in a VDL Mode 3 voice burst at the antenna port to the time when the MDR completes transmission of the HDLC voice burst message containing vocoder frame 1 to the RIU. [SRD 3.3.4.2.2]

3.5.1.2.5 Downlink Analog Voice Delay in MDR Receiver

a) The downlink audio processing delay contribution of the MDR receiver in analog voice modes via the PCM voice interface to the RIU **shall** be less than or equal to 83 ms, measured from MDR receiver squelch break to the time when the MDR receiver completes transmission of the second HDLC PCM voice message to the RIU. [SRD 3.3.4.2.2]

b) In sustainment mode, the audio processing delay in the MDR receiver, measured from the RF signal received at the MDR receiver antenna port to the corresponding demodulated analog voice output of the receiver, **shall** be less than 13 milliseconds. [SRD 3.3.4.2.2]

Note: This delay is due to the need to allow two frames of buffering to prevent underflow with the largest allowable PCM frame size of 25 ms. Further explanation is contained in Appendix F.

3.5.1.3 RESERVED

3.5.1.4 RESERVED

3.5.1.5 MDR System Timing

a) The time offsets for transmission arrival for VDL Mode 3 voice, data or management burst messages **shall** not deviate by more than ±10 microseconds from the MDR's timing reference point.

b) The time offsets for the reception window for VDL Mode 3 voice, data or management burst messages **shall** be accurate to ±10 microseconds.

Note: This implies that the time offset for transmission and subsequent reception arrival can be up to 20 microseconds from the system timing reference.

3.5.1.6 MDR Reliability/Maintainability

a) The MDR MTBF **shall** be equal to or greater than 26,280 operational hours. [SRD 3.5.3.1]

Note: The MDR is defined as a MDR transmitter and a MDR receiver.

3.5.2 RIU Performance Allocations

The following performance requirements apply only to the RIU.

3.5.2.1 RIU Subsystem Performance

3.5.2.1.1 RESERVED

3.5.2.1.2 RESERVED

3.5.2.1.3 RIU Subsystem Voice Operation

3.5.2.1.3.1 RIU Audio Processing Delay

Note 1: See Appendix F for further explanation regarding the audio delay.
Note 2: Some of the measurement points in this section are rather detailed as the MDR and MDR/RIU interface protocol are already defined at the time of writing this document.

3.5.2.1.3.1.1 Uplink Digital Voice Delay in RIU/Vocoding in GNI

a) In digital voice modes when vocoding in the GNI, the uplink audio processing delay contribution of the RIU **shall** be less than or equal to :

$$0.006 + \frac{(9 * N + 11)}{20{,}000}\,\text{sec},$$

Where, N is the number of vocoder frames in the voice burst message (1 to 4) from the GNI, and measured from reception of the HDLC voice burst message from the GNI to the time when the RIU completes relay transmission of the same HDLC voice burst message to the MDR. [SRD 3.3.4.2.1]

Note: This incurs a maximum allowable delay of 8.35.ms for N=4.

3.5.2.1.3.1.2 Uplink Analog Voice Delay in RIU

a) The uplink audio processing delay contribution of the RIU in analog voice modes with GNI vocoding **shall** be less than or equal to 75 ms, measured from the arrival of voice bursts from the GNI to the time when the RIU completes transmission of the second HDLC PCM voice burst message of the voice transmission to the MDR. [SRD 3.3.4.2.1]

Note 1: The above is to support VHF operation with GNI vocoding.

b) The uplink audio processing delay contribution of the RIU in analog voice modes with GNI vocoding **shall** be less than or equal to 30 ms, measured from the arrival of voice bursts from the GNI to the time when the audio is available at the RIU/Analog Radio interface. [SRD 3.3.4.2.1]

Note 2: The above is to support UHF operation with GNI vocoding.

3.5.2.1.3.1.3 Downlink Digital Voice Delay in RIU/Vocoding in GNI

a) In digital voice modes when vocoding within the GNI, the downlink audio processing delay contribution of the RIU **shall** be less than or equal to:

$$0.0119 + \frac{(9 * N + 11)}{4{,}375}\,\text{sec},$$

Where, N is the number of vocoder frames in the voice burst message received from the MDR, and measured time from reception of the MDR HDLC voice burst message to the time when the RIU completes relay transmission of the same HDLC voice burst message to the GNI. [SRD 3.3.4.2.2]

Note 3: This incurs a maximum allowable delay of 26.8 ms for N=6.

3.5.2.1.3.1.4 Downlink Analog Voice Delay in RIU

a) The downlink audio processing delay contribution of the RIU in analog voice modes via the PCM voice interface from the MDR **shall** be less than or equal to 87 ms, measured from the reception of the second complete MDR HDLC PCM voice message in an analog voice reception to the time when the RIU begins sending vocoded data to the GNI. [SRD 3.3.4.2.2]

Note 1: The above is to support VHF operation with GNI vocoding.

b) The downlink audio processing delay contribution of the RIU in analog voice modes via the analog radio interface **shall** be less than or equal to 87 ms, measured from the presence of audio at the RIU/Analog Radio interface to the time when the RIU begins sending vocoded data to the GNI. [SRD 3.3.4.2.2]

Note 2: The above is to support UHF operation with GNI vocoding

3.5.2.1.4 RIU Subsystem Data Operation

3.5.2.1.4.1 RIU/GNI Message Delays

a) The RIU **shall** complete the transmission of a valid DLS frame over the RIU/GNI telecommunications link no later than 500 ms after the last data burst message associated with the DLS frame is received from the MDR Receiver.

b) The RIU **shall** provide timing signals to the GNI to minimize end-end voice delay.

3.5.2.1.5 RESERVED

3.5.2.1.6 RESERVED

3.5.2.1.7 RESERVED

3.5.2.1.8 System Timing

a) The internal RIU 6-second epoch timing reference **shall** be locked to the Timing Source within a tolerance of ±10 microseconds. [SRD 3.2.14.3]

3.5.2.2 RIU Subsystem Interface

3.5.2.2.1 RESERVED

3.5.2.2.2 RESERVED

3.5.2.2.3 General Data Interfaces

a) The RIU **shall** interface at up to 9,600 bps communications on each of the general data interfaces. [FAA-E-2885]

b) The RIU **shall** provide an aggregate rate of at least 1,200 bps for all of the general data interfaces.

Note: The current RCE provides 880 bps total aggregate rate.

3.5.2.3 RESERVED

3.5.2.4 RIU Site Configuration

a) The RIU **shall** be located within 6,000 feet of the MDR transmitter to ensure proper timing of the MDR transmissions.

Note: There might be means to extend the distance beyond this limit, but it is the responsibility of the implementer to verify requirements can be achieved.

3.5.2.5 RIU/Telecommunications Interfaces

3.5.2.5.1 Transmission Path Failure Restoration

a) For transmission path failures where a redundant path exists, the RIU **shall** restore communications to the GNI via the alternate path within 3 seconds. [FAA-E-2885]

b) For communications loss less than 3 seconds in duration, the RIU **shall** restore communications to the GNI within {120} milliseconds.

c) Given a new telecommunications path, the RIU **shall** establish the connection for operational use within 3 seconds.

d) The RIU **shall** complete the switch back to the primary telecommunications link within {TBD} ms after receiving the GNI switching command without loss of data.

3.5.2.6 RESERVED

3.5.2.7 RESERVED

3.5.2.8 RIU Signaling

3.5.2.8.1 RIU Signaling Integrity

a) The RIU **shall** ensure that no more than one control signal in one million is falsely interpreted or not completed. [FAA-E-2885, 3.2.3.2.1]

3.5.2.8.2 RIU Signaling Delay

Note: Additional signaling delays shared between the GNI and RIU can be found in Section 3.5.3.2.2.2. Specific allocation of delays between the GNI and RIU are implementation issues for a lower level specification.

3.5.2.9 RIU Reliability/Maintainability

a) The RIU MTBF **shall** be equal to or greater than 40,000 operational hours. [RD 3.2.2; SRD 3.5.3.1, E.6]

3.5.3 GNI Performance Allocations

The following performance requirements apply only to the GNI subsystems.

3.5.3.1 GNI Subsystem Performance

3.5.3.1.1 RESERVED

3.5.3.1.2 GNI/Telecommunications Interface

3.5.3.1.2.1 Transmission Path Failure Restoration

a) For transmission path failures where a redundant path exists and configured for standby telecommunications backup, the GNI **shall** restore communications to the RIU via the alternate path within 1 second [FAA-E-2885, 3.2.2.4]

b) For communications loss less than 1 second in duration, the GNI **shall** restore communications to the RIU within 120 milliseconds. [SRD 3.3.3.8.2.b)]

c) Given a new telecommunications path, the GNI **shall** establish the connection for operational use within 3 seconds. [SRD 3.2.8.2]

d) The GNI **shall** complete the switch back to the primary telecommunications link in less than 3 seconds after the primary link is restored, with no loss of data when PTT is deactivated.

3.5.3.1.3 GNI/RIU Interface

a) The GNI **shall** support a control facility that interfaces to at least {350} RIUs. [SRD 3.3.4.4]

Note 1: Many control facilities will have significantly less than 350 RIUs connected. Therefore, a scalable GNI is specified in Section 3.4.3.1.3.
Note 2: This assumes a worst-case implementation without bundling multiple voice channels on an RIU. Bundling may reduce the number of RIUs that need to be supported depending on the System Configuration being used (e.g., up to 4 voice channels on an RIU for 4V).
Note 3: This requirement needs to be implemented in such a way that there is no singe point of failure.

3.5.3.1.4 RESERVED

3.5.3.1.5 RESERVED

3.5.3.1.6 RESERVED

3.5.3.1.7 RESERVED

3.5.3.1.8 General Data Interface

a) The GNI **shall** interface at up to 9,600 bps communications on each of the general data interfaces of Section 3.4.3.1.8. [FAA-E-2885]

b) The GNI **shall** provide an aggregate data rate of at least 1200 bps for all of the general data lines.

Note: Section a) indicates the interface speed, while b) specifies the actual communication bandwidth that can transfer general data across the lines between the GNI and RIU.

3.5.3.2 GNI Subsystem Communication Performance

3.5.3.2.1 RESERVED

3.5.3.2.2 Signaling

3.5.3.2.2.1 GNI Signaling Integrity

a) The GNI **shall** ensure that no more than one control signal in one million is falsely interpreted or not completed. [FAA-E-2885, 3.2.3.2.1]

3.5.3.2.2.2 GNI/RIU Signaling Delay

All of the following event response times are performed without telecommunications delays between the RIU and the GNI for both VHF and UHF signals, as appropriate.

3.5.3.2.2.2.1 Radio PTT/PTT Release

a) The response time from the instant the control site subsystem receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes the PTT signal at the RIU/Analog Radio interface **shall** not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]

b) The response time from the instant the control site subsystem receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes PCM voice packets at the RIU/MDR interface **shall** not exceed 143 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]

c) The response time from the instant the GNI receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes VDL Mode 3 voice packets at the RIU/MDR interface shall not exceed 165 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]

3.5.3.2.2.2.2 Radio PTT/PTT Release Confirmation

a) The response time from the instant the RIU provides/removes the keying signal at the RIU/Analog Radio interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]

b) The response time from the instant the RIU provides/removes the PCM voice bursts at the RIU/MDR interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]

c) The response time from the instant the RIU provides/removes the VDL Mode 3 voice bursts at the RIU/MDR interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]

3.5.3.2.2.2.3 Radio Squelch Break/Squelch Break Release

a) The response time from the instant the Analog Radio provides/removes the squelch break/squelch break release signal at the RIU/Analog Radio interface, to the instant that the squelch break/squelch break release signal appears at the NEXCOM/VSCE interface **shall** not exceed 200 ms for 99.9% of the events.

Note: There is no current specification on the squelch break signal, so the performance number is based on being only slightly longer than the downlink audio delay so that the signal does not significantly lag the presence of audio.

b) The response time from the instant the MDR provides/removes voice bursts at the RIU/MDR interface, to the instant that the control site subsystem provides a squelch break/squelch break release indication at the NEXCOM/VSCE interface **shall** not exceed 100 ms for 99.9% of the events.

3.5.3.2.2.2.4 Main/Standby Select/Deselect

a) The response time from the instant the VSCE provides the M/S Select/Deselect signal at the NEXCOM/VSCE interface, to the instant the remote site RIU executes both of the following actions **shall** not exceed 100 ms for 99.9% of the events: [FAA-E-2885, 3.2.3.2.2.2]

1. Switches to the selected main or standby transmitter/receiver, that is, routes the voice and control signals only to/from the selected transmitter/receiver
2. Provides the necessary signaling to the antenna transfer relay via the remote site RIU/Radio interface

3.5.3.2.2.2.5 Main/Standby Select/Deselect Confirmation

a) The response time from the instant the RIU completes all M/S Select/Deselect actions (i.e., (1) and (2) of {3.5.3.7.4a}), to the instant the control site subsystem provides a M/S Select/Deselect Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 250 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.2.1]

3.5.3.2.2.2.6 Receiver Mute/Unmute

a) When configured for RIU Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the receive voice signal is muted/unmuted within the RIU **shall** not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]

b) When configured for Radio Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the signal is available at the RIU/Analog Radio interface **shall** not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]

c) When configured for Radio Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the signal is available at the RIU/MDR interface **shall** not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]

3.5.3.2.2.2.7 Receiver Mute/Unmute Confirmation

a) The response time from the instant the voice signal is muted/unmuted in the RIU to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]

b) The response time from the instant the Receiver Mute/Unmute Confirmation signal is available at the RIU/Analog Radio interface to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]

c) The response time from the instant the Receiver Mute/Unmute Confirmation signal is available at the RIU/MDR interface to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface **shall** not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]

3.5.3.2.2.2.8 VDL Mode 3 Voice Preemption/Preemption Release

a) The voice preemption signal **shall** be contained in the next scheduled uplink Beacon that occurs at least 50 ms after the reception of the voice preemption and PTT signals from the NEXCOM/VSCE interface for 99.9% of the preemption events. [RD 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1, 4.6]

3.5.3.2.2.2.9 VDL Mode 3 Voice Preemption/Preemption Release Confirmation

a) The response time from the instant the VDL Mode 3 voice preemption /preemption release confirmation signal is generated at the RIU to the instant when the voice preemption/preemption release confirmation signal is received at the NEXCOM/VSCE interface **shall** not exceed 340ms for 99.9% of the events. [RD 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1, 4.6]

3.5.3.2.2.2.10 VHF/UHF Lockout/Lockout Release

a) The response time from the instant the VHF/UHF lockout/lockout release condition is declared in the RIU to the instant when the control site subsystem is notified of the VHF/UHF Lockout/lockout release condition **shall** not exceed 120ms for 99.9% of the events. [RD 3.1.6.1; SRD 3.2.4.2a]

3.5.3.3 GNI Voice Subsystem Operation

3.5.3.3.1 GNI Audio Processing Delay

3.5.3.3.1.1 Uplink Digital Voice Delay in GNI

a) The uplink audio processing delay contribution of a GNI subsystem when vocoding **shall** be less than or equal to 72ms + (5-Nsil)*20ms in digital voice modes, where Nsil is the number of vocoder silence frames transmitted in vocoder frames 1-5 ($0 \le Nsil \le 5$), and measured from VSCE Push-to-talk activation to the time when the GNI completes transmission of the HDLC voice burst message containing vocoder frame 6 of the first VDL Mode 3 voice burst transmitted to the RIU. [RD 3.2.7.1; SRD 3.3.4.2.1]

*Note: The maximum GNI+RIU+MDR uplink audio delay is the above delay + 7 ms (RIU relay) + Nsil*20ms - 6ms = 173 ms since vocoder frame 1 modulation is completed 6ms prior to the time when vocoder frame 6 voice burst message is received at the MDR.*

3.5.3.3.1.1.1 Downlink Digital Voice Delay in GNI

a) The downlink audio processing delay contribution of a GNI subsystem when vocoding **shall** be less than or equal to 61 ms, measured as the time difference between the time specified in the Time of Arrival (TOA) field of the HDLC voice burst message from the RIU/MDR and the time when the GNI begins audio output of the first vocoder frame in the same voice burst message. [RD 3.2.7.1; SRD 3.3.4.2.2]

3.5.3.4 GNI Subsystem Data Operation

3.5.3.4.1 GNI Data Processing Delay

a) The processing delay for multiplexing VDL Mode 3 voice and data of a GNI subsystem **shall** be less than 10 ms.

b) MMC data processing **shall** not delay uplink or downlink voice and control data processing or distribution.

3.5.3.4.2 GNI Connectivity Report Time

a) The GNI **shall** comply with connectivity reporting time requirements of ATSC Class B of Section 3.3.3.2.1.4. [SRD 3.3.3.2.1.4]

3.5.3.5 RESERVED

3.5.3.6 GNI Reliability/Maintainability

a) The GNI MTBF **shall** be equal to or greater than 30,000 operational hours. [RD 3.2.1.2, 3.2.2; SRD 3.5.3.1, E.6, E.7]

Note 1: While 10,000 hours would achieve the 0.99999 level of service availability with a redundant backup, the MTBF is increased to reduce the number of maintenance actions to around 1 per 2 years.
Note 2: This is based on the string, or thread, associated with the GNI and RIU.

3.5.4 A/G Router Performance Allocations

The following performance requirements apply only to the A/G Router subsystems.

3.5.4.1 Air/Ground Routing

3.5.4.1.1 A/G Router Capacity

a) Each A/G Router **shall** be capable of supporting up to 1000 aircraft. [SRD 3.2.17.6, 3.3.5.4]

3.5.4.1.2 A/G Router Traffic Loading

a) The A/G Router **shall** process {1500} join events per hour.[SRD 3.2.17.4, 3.3.5.4]

b) The A/G Router **shall** process {1500} leave events per hour. [SRD 3.2.17.4, 3.3.5.2]

c) The A/G Router **shall** process {55} Network Protocol Data Units (NPDU) per second, each of 256 octets in length. [SRD 3.3.5.4]

Note: The above performance requirements assume the use of Regional Backbone routers to limit the distribution of route updates within the ATN network.

3.5.4.2 RESERVED

3.5.4.3 A/G Router Reliability/Maintainability

a) The A/G Router MTBF **shall** be equal to or greater than 19,996 operational hours. [SRD 3.5.3.1, E.5]

Note: To meet a service availability of 0.99999 for critical service, there will need to be a second router path available to each GNI.

3.5.5 MDT Performance Allocations

RESERVED

3.5.6 MMCWS Performance Allocations

RESERVED

3.5.7 Timing Source

3.5.7.1 Time Conditioning

a) The Timing Source **shall** maintain system timing within ± 3 microseconds (ms) of the Timing Reference. [SRD 3.3.6.1.1.d]

Note: The system is budgeted to allow ½ symbol timing error (47.1 ms) between radio sites on the same frequency in the same cover age area (e.g., RCAG/BUEC, or diversity site groups). SRD 3.3.6.1.1 Note]

3.5.7.2 Time Drift

a) With the loss of the external Timing Reference conditioning, the Timing Source **shall** maintain system timing for at least 30 days without degrading system operation due to timing. [SRD 3.3.6.2.a]

Note: This equates to requiring the Timing Source to drift at a rate no greater than 0.0139 ms/hour (0.33 ms/day) before timing boundaries are violated for a 200 nmi sector, or at 0.675 ms/hour (16.2 ms/day) for a 160 nmi sector. Three slot sectors have significantly more guard time that can be used for timing uncertainty. For example, a 240 nmi sector would need a drift rate of no greater than 6.36 ms/hour (152.7 ms/day) to maintain timing for 30 days. [SRD 3.3.6.2 Note]

3.5.7.3 Time Standard

a) The Timing Source **shall** be aligned with UTC on 6 January 1980. [SRD 3.3.6.3.a]

Note: The above requirement implies that leap seconds are not compensated for, as leap second adjustments would perturb the operation of the system. GPS is one system that it aligned with UTC on 6 January 1980. Any other absolute time source which is traceable to UTC without leap second adjustments is also suitable as an external Timing Reference for VDL Mode 3. [SRD 3.3.6.3 Note]

3.6 EXTERNAL FUNCTIONAL ALLOCATIONS

The NEXCOM System is integrated with, and dependent on other elements of the NAS. Some of the NEXCOM's functionality depends on interfaces with and/or enhancements of other NAS elements. The NEXCOM program will jointly develop IRDs for such interfaces. Functions allocated external to the NEXCOM equipment are described in the following subsections.

3.6.1 Voice Switch Functional Requirements

NEXCOM will add new features and capabilities for AT controllers. NEXCOM has functional interfaces to VSCE equipment. In order to make the new capabilities and features available the VSCE and controller interface will require modifications.

3.6.1.1 Voice Switches Affected

The following is a representative list of voice switches that will need to change to implement NEXCOM features and new capabilities:

- VSCS
- ETVS
- RDVS
- STVS
- AFSSVS

3.6.1.2 Voice Switch Function Affected

The changes described here are NEXCOM VDL Mode 3 capabilities.

3.6.1.2.1 Preemption of Aircraft Voice Transmissions (Controller Override)

The feature allows the AT controller to assert priority over voice communications regardless of the channel status. It is also referred to as controller override.

a) The VSCE controller interface **shall** generate a voice preemption signal, when in presence of a PTT, serves to terminate all PTT voice transmission within a Talk Group [RD 3.3.1, 3.3.2; RTCA/DO-224A section 3.3.2.1.1].

b) The VSCE **shall** deliver the preemption signal to the NEXCOM System interface.

Note 1: This gives the controller the capability to un-key a stuck microphone of a member of the Talk Group.
Note 2: For activation of the preemption, the voice preemption signal needs to be present in conjunction with a PTT from the VSCE.

3.6.1.2.2 Radio Resource Selection Confirmation

This capability is provided in NEXCOM to indicate to the user the operational status of the link. This is intended to allow the controller to know on which radio he or she is actively transmitting.

a) The VSCE **shall** indicate to each controller the actual configuration of the equipment supporting that controller's Talk Group based on feedback from the NEXCOM System [RD 3.1.1.4].

Note: NEXCOM will indicate to the VSCE by a signal from the transmit/receive site which transmitter and receiver is active. The VSCE indicates to the controller which equipment is selected.

3.6.1.2.3 Channel Busy Signal

The channel status feature indicates to a user that the channel access or request has been denied. It is akin to a "channel busy" signal. The users only see their own channel denial, not the denials of the channel to other users.

a) The VSCE **shall** provide an indication to the controller that the requested channel is occupied [SRD 3.2.4; RTCA/DO-224a, 3.3.5.4.3].

Note: This is needed to support the dual control function of NEXCOM. It also indicates to a controller that the channel is occupied by an aircraft keying up for transmission [DO-224a, 3.3.5.4.3]. It indicates to the controller that the channel is occupied.

3.6.1.2.4 Status of Transmissions (RF Activity)

This requirement is intended to give the controller a continual awareness of the status of the channel activation. This allows the controller to know if the transmitter is operating when the push-to-talk is activated and when the receiver is receiving.

a) The VSCE **shall** continually indicate to the controller transmit channel status via PTT confirmation [RD 3.1.7.1].

b) The VSCE **shall** continually indicate to the controller receive channel status via squelch break [RD 3.1.7.1].

Note: NEXCOM will provide input to the VSCE to indicate to the controller that the transmitter has been activated and the receiver is active.

3.6.1.2.5 Channel Labeling

This requirement provides capability for the VSCE to select A/G channels that are added as a result of introducing NEXCOM.

a) The VSCE A/G channel selector **shall** display six numerical characters in accordance with ICAO Annex 10, Vol. V, Ch. 4 [ICAO Annex 10, Vol. V, Ch. 4].

Note: The VSCE needs to support channel labeling for all NEXCOM modes, i.e., VDL Mode 3, DSB-AM 25kHz, and DSB-AM 8.33 kHz.

3.6.2 Telecommunications Functional Requirements

3.6.2.1 Support for Voice, Data and Signaling

a) Telecommunications links **shall** support voice, data and signaling for the NEXCOM System.

3.6.2.2 Telecommunications Interfaces

a) Telecommunications circuits **shall** interface via either 4-wire or DDC, as needed.

Note: See Section 3.2.3.8.1 in SRD.

3.6.2.3 Physical Path Diversity

a) Telecommunications **shall** provide at least one telecommunications circuit between an RIU and its associated GNI.

b) Telecommunications **shall** provide two physically diverse telecommunications circuits for connectivity for selected A/G Communications sites.

Note: This requirement varies on a site-by-site basis. AF regional administrators decide the BUEC site connectivity requirement.

3.6.2.4 Telecommunications Availability

a) Telecommunications **shall** support A/G voice and data service.

3.6.3 NAS Infrastructure Management System (NIMS) Functional Requirements

a) The NIMS **shall** interface with the NEXCOM System via an interface compliant with FAA-E-2911 and the NEXCOM/NIMS Interface Control Document (ICD), NAS-IC-TBD.

b) The NIMS **shall** provide a Computer Human Interface (CHI) for the Remote Maintenance Monitor functions of the NEXCOM System.

c) The NIMS **shall** allow dial-up connection to allow authorized NEXCOM users using NIMS MDT software authentication to access the NEXCOM MMC functions.

d) NIMS **shall** assign for each NIMS user authorized to access the NEXCOM MMC for each associated pre-defined privilege level to the NEXCOM/NIMS interface.

e) The NIMS **shall** assign the associated NEXCOM access privilege level to the NEXCOM/NIMS interface.

f) The NIMS **shall** provide mapping from the NIMS users to their associated privilege levels.

Note: The privilege level information will be used by the GNI to determine the specific MMC functions available to users with that privilege level.

3.6.3.1 NIMS/NEXCOM Interface

a) The NIMS interface to the NEXCOM System **shall** be located at the control site.

3.6.3.1.1 Status Monitoring

a) The NIMS **shall** provide status monitoring of the NEXCOM (sub)system(s).

3.6.3.1.2 Control

a) The NIMS **shall** control the NEXCOM (sub)system(s).

3.6.3.1.3 Performance Monitoring

a) The NIMS **shall** provide performance monitoring of the NEXCOM (sub)system(s).

3.6.3.1.4 Fault Isolation

a) The NIMS **shall** access the fault isolation data capabilities of the NEXCOM (sub)system(s).

3.6.3.1.5 Service/Equipment Certification

a) The NIMS **shall** provide access to those functions that are provided by the NEXCOM System for Service/Equipment Certification.

3.6.3.1.6 Digital Link Integrity

a) The NIMS **shall** provide monitoring status of the Digital Link Integrity provided by the NEXCOM System.

3.6.3.1.7 UHF Interface

a) The NEXCOM System **shall** collect, transport, and provide to the NIMS interface the RMM functionality of the UHF radios co-located with NEXCOM MDRs in accordance with the NEXCOM/NIMS ICD UHF radio subsections.

3.6.3.2 NIMS Security

The following requirements are based on NAS ISS Architecture and NAS ISS Requirements documents. This minimum set of requirements allows for a trusted environment, which enables the exchange of information between the NIMS and the NEXCOM System.

a) The NIMS **shall** support the assignment of a unique logon identifier for each user.

b) The NIMS **shall** authenticate the claimed user's identity before allowing the user to perform any actions other than a well-defined set of operations.

c) When passwords are to be used for authentication, the NIMS **shall** use strong passwords (e.g., prevent the use of dictionary words).

d) The NIMS **shall** enforce mandatory password changes at set intervals.

e) The NIMS **shall** prevent the reuse of passwords on a per user basis.

f) The NIMS **shall** implement strong authentication.

g) The NIMS **shall** enable access authorization management; i.e., the initialization, assignment, and modification of access rights (e.g., read, write, and execute) to NEXCOM MMC functions with respect to (1) group membership (privilege level); and (2) such constraints as port-of-entry.

h) The NIMS **shall** temporarily (a configurable period of time) suspend user accounts after a configurable number of consecutive failed logon attempts.

i) The NIMS **shall** protect NEXCOM information system security data and functionality from all unauthorized access.

j) The NIMS **shall** terminate NEXCOM control access to any subsystem after a configurable amount of NEXCOM control access inactivity.

3.6.4 Automation Functional Requirements

NEXCOM interfaces the automation system via the GNI and the control site operations LAN. NEXCOM data capabilities will require modifications of the automation system.

3.6.4.1 Automation Subsystems Affected

The following is a representative list of automation systems affected by NEXCOM features and capabilities:

- CPDLC
- ARTS
- DSR
- Host
- STARS

3.6.4.2 Automation Functions Affected

The NEXCOM capabilities relate primarily to VDL Mode 3.

3.6.4.2.1 Next Channel Uplink Information

The next channel uplink information is sent from the ground to the aircraft control head for setting the aircraft radio to the channel on which it will communicate with the next AT controller on its flight route. It is a capability embedded in the CPDLC.

a) The CPDLC **shall** have the capability to provide the next radio channel setting information to the NEXCOM System. [RD, Attachment 2, Automatic Transfer of Communication]

b) Next Channel Uplink information **shall** be recorded.

Note: This recording requirement is to support NTSB requirements to record communication between the controller and pilots.

3.6.4.2.2 Urgent Downlink Request

The urgent downlink request feature allows an aircraft in the Talk Group to indicate to the controller the need for downlink communications requiring high priority attention.

a) The automation system **shall** receive urgent downlink requests from the NEXCOM System and display to the controller. [RD Attachment 2, Queuing of Urgency Calls].

3.6.4.2.3 Aircraft Logged In Feature

The aircraft logged in feature notifies the controller that an aircraft is a participant in the Talk Group. It displays to the controller the ICAO address of the aircraft in the sector that are listening. If the ICAO address is not displayed, the aircraft does not listen; however, its presence is known from radar data.

a) The automation system **shall** provide the capability of displaying to the operator all logged in members of a Talk Group based on input from the NEXCOM System.

3.6.4.2.4 Talker ID Feature

The Talker ID feature indicates which aircraft is talking on the voice channel.

a) The automation system **shall** indicate which aircraft is talking on the voice channel to the controller display based on input from the NEXCOM System.

3.6.4.2.5 Data Interface

a) The CPDLC automation system **shall** interface the NEXCOM A/G Router to the ATN network.

3.6.4.3 Security Management

a) Automation **shall** implement a Public Key Infrastructure (PKI).

Note: This is not necessarily an assignment to any of the identified programs in section 3.6.4.1. It may require the FAA to establish a new program to support this capability.

b) Automation's PKI **shall** support and maintain the key management of NEXCOM Subsystems.

3.7 EXTERNAL PERFORMANCE ALLOCATIONS

The External Functional Requirements addressed in Section 3.6 have performance implications associated that are outlined in the following subsections.

3.7.1 VSCE Performance Affected

In this section the performance requirements of VSCE equipment interfacing with NEXCOM are specified. Performance is generally expressed as latency, i.e., transit time through the VSCE. The corresponding NEXCOM System performance allocations are given in Section 3.3.6.

3.7.1.1 Preemption of Aircraft Voice Transmissions Performance

a) The VSCE **shall** deliver the preemption signal within 50 ms of activation by user for 99.9% of the events.

b) The VSCE **shall** indicate, to the controller, confirmation of voice preemption activation within 200 ms of receipt a confirmation signal from the NEXCOM System for 99.9% of the events.

Note 1: This latency requirement is in line with VSCE equipment PTT confirmation latency specifications.
Note 2: The latency requirement for the preemption signal performance needs to be consistent with PTT and PTT confirmation performance.

3.7.1.2 Radio Resource Selection Confirmation Performance

a) The VSCE latency for the radio resource selection confirmation signal (e.g., Main/Standby Select/Deselect Confirmation or BUEC Select/Reset Confirmation) **shall** be at most 150 ms for 99.9% of the radio resource selection events.

Note: This latency requirement is in line with performance specifications for indicator signal processing in existing VSCE equipment (e.g., confirmation of M/S TX/RX transfer).

3.7.1.3 Channel Busy Signal Performance

a) The VSCE latency for the channel busy indicator **shall** be at most 150 ms for 99.9% of the channel busy events.

Note: This latency specification is in line with indicator latencies specified for VSCE (e.g., receiver muting confirmation or M/S TX/RX transfer confirmation).

3.7.1.4 Performance of Status of Transmissions

a) The VSCE latency for the controller PTT/PTT Release Confirmation indication **shall** be at most 200 ms for 99.9% of the PTT confirmation events.

b) The VSCE latency for the squelch break indication **shall** be at most 150 ms for 99.9% of the squelch break indication events.

Note: This latency requirement is in line with performance specifications for indicator signal in existing VSCE equipment (e.g., receiver muting confirmation or M/S TX/RX transfer confirmation).

3.7.2 Telecommunications Performance Requirements

3.7.2.1 Support for Voice, Data and Signaling

3.7.2.1.1 Telecommunications Latency

a) One-way transfer delay contribution from terrestrial telecommunications alone **shall** not exceed 250 ms. [RD 3.2.7.1]

3.7.2.1.2 Line Characteristics

a) Analog telecommunications **shall** meet the performance requirements as specified in *Bellcore TR-NWT-000335 Voice Grade Special Access Service Transmission Parameter Limits and Interface Combinations, May 1993*.

b) Digital telecommunications **shall** meet the performance requirements as specified in *Bellcore GR-499-CORE Transport Systems Generic Requirements (TSGR) Common Requirements, December 1998*.

c) Digital telecommunications connectivity **shall** provide a minimum of 99.9 percent error-free seconds for any 24-hour period.

Note: An error free second is a second in which no bit errors are received.

3.7.2.2 RESERVED

3.7.2.3 RESERVED

3.7.2.4 Telecommunications Availability

a) Telecommunications paths **shall** provide an availability of at least 0.998. [SRD App E]

Note 1: FAA Order 6000.36 on Communications Diversity requires all defined services in Appendix 1 of the Order, including all A/G telecommunications for all operational environments, be provided diversity utilizing service and/or circuit diversity.
Note 2: Any exceptions to FAA Order 6000.36 must be jointly approved by the regional Airway Facilities and Air Traffic division managers and forwarded to the national oversight committee.

3.7.3 NIMS Performance Requirements

a) The NIMS **shall** provide NEXCOM System RMM performance characteristics in accordance with FAA-E-2911, 3.2.3 a).

b) The NIMS **shall** not interfere with the operational performance of the NEXCOM System.

c) The NIMS **shall** accommodate low data (high latency) rates.

3.7.4 Automation Performance Requirements

TBD

4 VERIFICATION

4.1 Critical Operational Issues

The following is the list of Critical Operational Issues:

1. Does NEXCOM interface and operate with existing equipment and systems?
2. Can NEXCOM be used without disruption or degradation to ATC operations?
3. Does NEXCOM provide the required level of reliability, maintainability and availability?
4. Can NEXCOM be maintained without disruption or degradation of current ATC operations?
5. Can NEXCOM (maintain at least) provide the current level of efficiency and accuracy of communications between the controller and pilot?
6. Does NEXCOM voice quality afford the required performance for effective exchange of controller and pilot communications?
7. Is AT and Airway Facilities (AF) training sufficient to allow AT to effectively operate the system and AF to effectively maintain the system?
8. Do NEXCOM National Airspace Integrated Logistics Support (NAILS) elements provide for effective operation, maintenance and support when deployed in the NAS?
9. Does the NEXCOM Remote Maintenance Monitoring System (RMMS) allow the technician to perform monitor and control activities from a remote location?

4.2 Test and Evaluation Requirements

Test and Evaluation (T&E) will be conducted by the FAA in accordance with Acquisition Reform Interim Guidance (ARIG) 96-1 and Acquisition Management System (AMS) Test & Evaluation (T&E) Process Guidelines, to test and evaluate system operational effectiveness and suitability including compatibility, interoperability, degraded operations, maintainability and supportability. T&E also identifies deficiencies in NAS hardware, software, security, human performance factors, critical operational issues (COIs) and/or operational concepts. Relational steps of systematic testing may include many of the following: Research and Development (R&D) Prototype Testing; Developmental Testing (DT); Operational Capability Demonstration (OCD) and/or Operational Capability Testing (OCT) for COTS/NDI acquisitions; First Article Test or Factory Acceptance Test (FAT); Operational Test (OT); Production Acceptance Test (PAT); Site Acceptance Testing (SAT); and Field Familiarization (conducted by Airway Facilities (AF) and Air Traffic (AT)). The system will be subject to independent penetration testing. Additionally, the NEXCOM System has been identified for Independent Operational Test and Evaluation (IOT&E) which is conducted by the Office of Independent Operational Test and Evaluation (ATQ). Upon completion of OT, the IPT will notify ATQ via an Independent Operational Test and Evaluation Readiness Declaration (IOTRD) to conduct IOT&E. After OT and/or IOT&E and completion of Field Familiarization, the system will enter the in-service decision (ISD) for the go ahead to achieve Initial Operational Capability (IOC) and then Operation Suitability Demonstration (OSD). The successful completion of OSD signifies the Operational Readiness Date (ORD) and acceptance of the new system.

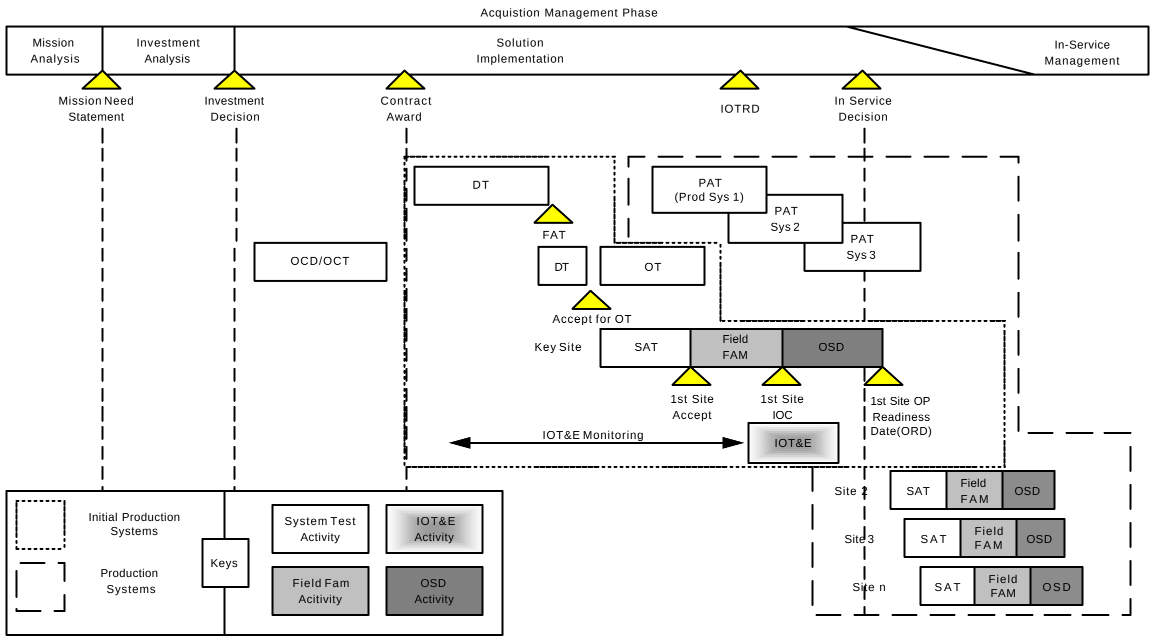


Figure 4-1. Tests and Test Activities

4.2.1 System Test

The NEXCOM Integrated Product Team (IPT) will lead the NEXCOM System test to verify contractual operational requirements and COIs. The following provides a synopsis of the test activities of System Test. Upon completion of OT, the IPT will issue the IOTRD to begin IOT&E

4.2.1.1 Developmental Test

The objective of Developmental Test (DT) will be to verify that all technical and performance requirements specified in the developmental portion of the contract have been met. DT normally will be performed by the contractor and witnessed by the product team at the factory and/or the William J. Hughes Technical Center (WJHTC). DT will begin with a series of hardware and software tests. Hardware tests will be at the Lowest Replaceable Unit (LRU) level and proceed to the (sub)system level. The tests will verify achievement of requirements relating to such factors as timing, RF performance, thermal stress, and electromagnetic interference. Software testing will verify the most detailed requirements at the unit level and proceed to verify higher-level integrated requirements at the segment level and, finally, to verify requirements at the computer software configuration item (CSCI) level. Developmental testing at the vendor's facility will conclude with a design qualification test that demonstrates the system's ability to satisfy the (sub)system specification(s).
Factory acceptance will be contingent on successful completion of the design qualification tests. If necessary, DT may be continued at the WJHTC in an environment that more closely replicates the actual field environment, i.e., real versus simulated interfaces. DT will verify that the system meets contract requirements. Entrance criteria include baselined requirements, a completed and approved Contractor Master Test Plan (CMTP), and approved test procedures. DT exit criteria or successful completion of DT testing requires that:

- All test scripts have been executed and program trouble reports (PTRs) have been generated for each failure.
- All PTRs have been resolved, i.e., PTRs have been fixed or deferred to a later release with government approval.

- All changes made as a result of PTRs have been tested.
- The test report has been reviewed and approved.
- All documentation associated with the systems has been updated to reflect changes made during testing.

Acceptance of the system is contingent on successful completion of DT.

Factory Acceptance Tests (FATs) will verify that the NEXCOM System meet all requirements, such as but not limited to the applicable sections of Title 29 & 40 of the CFR, and other applicable orders and directives. The vendor for each NEXCOM Subsystem will be responsible for performing the FAA witnessed FATs.

4.2.1.2 Operational Test

The Operational Test (OT) will be conducted at the WJHTC for the NEXCOM System and each subsystem. The OT will consist of integration tests, suitability tests and effectiveness tests. These tests will ensure that operational requirements have been met and that all Critical Operational Issues (COIs) have been resolved.

OT integration testing will verify that the system interfaces to the existing elements of the NAS and that the NAS can operate with the new (sub)system. Interface testing with future NAS elements may be provided through the use of simulators where warranted.

OT suitability testing will evaluate the degree to which the (sub)system intended for field use satisfies its availability, compatibility, transportability, interoperability, reliability, maintainability, safety, human factors, logistics supportability, documentation, FAA maintenance handbook and certification criteria, personnel, and training requirements. OT suitability testing also includes an assessment of the COIs.

OT effectiveness testing will evaluate the degree to which the (sub)system accomplishes its mission when used by representative personnel in the expected operational environment. This testing will include capacity and NAS loading, degraded mode operations, safety, security, and transition switchover. Key site personnel will operate the equipment for some of these tests, because they are the “most representative” operators, and so they can become familiar with the system. This approach will reduce the learning curve and minimize disruption when the (sub)system is installed at the key site. Effectiveness and suitability testing and evaluation may be continued at the key site(s) if a complete assessment cannot be accomplished at WJHTC. OT effectiveness testing will also assess COIs.

Entrance criteria for OT include successful completion of DT/FAT; baselined, configuration-managed technical documentation, software, and hardware; and completion of user training. After the successful conclusion of OT, the IPT will declare the system ready for IOT&E via the IOT&E Readiness Declaration (IOTRD) (for those programs designated for IOT&E). The IOTRD will address the IOT&E prerequisites/ requirements as detailed in the T&E section of the ASP.

4.2.1.3 Production Acceptance Test (PAT)

The FAA witnessed PAT (a subset of the DT/FAT) will be conducted to verify that the assembly line is producing units that have the same quality and performance as the DT/FAT.

4.2.1.4 Site Acceptance Test (SAT)

The FAA will conduct installation and check-out (INCO) and SAT. These tests will ensure that the system is installed and functioning properly.

4.2.1.5 Field Familiarization

Field familiarization will be conducted by AT and AF field personnel at each new site to which the new (sub)system is delivered. Field familiarization will be performed as the last part of System Testing , and the primary objective will be to verify that the site is ready to transition to the new (sub)system. This verification will include: ensuring that the new (sub)system has been properly installed and interfaced to the existing NAS; that operational procedures and system documentation are in place; that proper logistics and support are available; and that site personnel are adequately trained and ready to use the new system. Testing will be conducted at each site by field site AF and AT personnel after the system has successfully completed installation and check-out (INCO) testing and SAT. Field familiarization will follow contract acceptance inspection (CAI) and lead to IOC. IOC will be the declaration by site personnel that the (sub)system is ready for conditional operational use in the NAS and will denote the end of field familiarization at that site.
Field familiarization tests at each field site may include:

- Testing to confirm that the system can be safely transitioned to a secure system;
- Testing to confirm that all security requirements are implemented;
- Testing to confirm that the system is functionally and operationally suitable;
- Testing to confirm that the system can be certified without degrading other system operations;
- Maintenance testing to confirm that hardware and software maintenance can be completed without degrading system performance and security;
- Failure Mode testing to confirm that the system can report, recover, reconfigure if necessary, and be repaired and recertified without degrading system performance; and
- Portions of IOT&E, if applicable.

Field familiarization tests will be designed such that any residual operational deficiencies that the new (sub)system might have are revealed before IOC.

Typical entrance criteria for field familiarization tests are:

1. CAI is successfully completed
2. Test plan and procedures are approved and ready
3. Hardware/software are at correct release/revision levels
4. Certification procedures are in place
5. Documentation and maintenance handbooks are in place
6. Test equipment and tools are in place
7. Site personnel are adequately trained and ready for testing
8. There are no open test-critical PTRs.

Typical field familiarization test exit criteria are:

1. Successful completion of the field familiarization test plan.
2. AF/AT final test report submitted; AF/AT test directors recommend proceeding to IOC.
3. Successful regression testing of any hardware/software releases/revisions that were installed during testing.
4. No Test Critical or Type 1 PTRs outstanding and no more than a predefined number of non Type 1 PTRs open.
5. AF/AT managers declare IOC.

4.2.2 IOT&E

ATQ will lead the ATS test team for IOT&E, consisting of AT and AF operational experts. The ATS test team will first monitor the system test, and then will perform the IOT&E, assessing the operational readiness of the system based on identified COIs from Section 4.1 of this document. The ATS test team will report their results to ATS-1.

4.3 Methods of Verification

The following verification methods will be utilized in measuring equipment performance and compliance of individual requirements contained in the purchase description of each NEXCOM Subsystem. The four verification methods, (TEST, DEMONSTRATION, ANALYSIS, and INSPECTION), listed in decreasing order of complexity, are described as follows:

1. TEST. Test is a method of verification wherein performance is measured during or after the controlled application of functional and/or environmental stimuli. Quantitative measurements are analyzed to determine the degree of compliance. The process uses laboratory equipment, procedures, items, and services.
2. DEMONSTRATION. Demonstration is a method of verification where qualitative determination of properties is made for an end item, including the use of technical data and documentation. The items being verified are observed, but not quantitatively measured, in a dynamic state.
3. ANALYSIS. Analysis is a method of verification that consists of comparing hardware design with known scientific and technical principles, procedures and practices to estimate the capability of the proposed design to meet the mission and system requirements.
4. INSPECTION. Inspection is a method of verification to determine compliance without the use of special laboratory appliances, procedures, or services, and consists of a non-destructive static-state examination of the hardware, the technical data and documentation.

5 NOTES

5.1 Government Furnished Property

The MDT hardware and operating system is considered government furnished property for the development of the NEXCOM System and subsystems. The MDR is also considered government furnished property for the development of the NEXCOM System and subsystems.

5.2 ICAO Standardization Agreements

VDL Mode 3 standards and documentation are due for publication in November 2001.

5.3 Other Guidance Material

5.4 References

ABBREVIATIONS AND ACRONYMS

A/G	Air/Ground
ACARS	Aircraft Communications Addressing and Reporting System
ACF	Area Control Facility
ADL	Aeronautical Data Link
AF	Airway Facilities
AFSS	Automated Flight Service Station
AM(R)S	Aeronautical Mobile (Route) Services
ANICS	Alaskan NAS Interfacility Communications System
ARIG	Acquisition Reform Interim Guidance
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ASP	Acquisition Strategy Paper
AT	Air Traffic
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
ATN	Aeronautical Telecommunication Network
ATR	Antenna Transfer Relay
ATS	Air Traffic Services
BIT	Built-In Test
BUEC	Backup Emergency Communications
CFR	Code of Federal Regulations
CLNP	Connection-Less Network Protocol
COI	Critical Operational Issue
CPDLC	Controller Pilot Data Link Communications
C-RCE	Control-Radio Control Equipment
D-ATIS	Digital Air Traffic Information Service
DC	Direct Current
DLS	Data Link Service or Data Link Sub layer
DSB-AM	Double Sideband Amplitude Modulation
DSR	Display System Replacement
DSRCE	Down Scoped Radio Control Equipment
ECOM	En Route Communications
EEM	Electronic Equipment Modification
EMI	Electromagnetic Interference
ETVS	Enhanced Terminal Voice Switch
EUL-A	End User Location - Type A
EUL-B	End User Location - Type B
FAA	Federal Aviation Administration

FAATSAT	FAA Telecommunications Satellite
FEC	Forward Error Correction
FIFO	First In First Out
FIS	Flight Information Services
FPAM	Front Panel Accessible MMC
FSS	Flight Service Station
G/G	Ground to/from Ground
GNI	Ground Network Interface
GNIp	Primary GNI
GNIs	Secondary GNI
GPS	Global Positioning System
Hr	Hour
HDLC	High-Level Data Link Control
HVAC	Heating, Ventilation and Air Conditioning
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
ICSS	Integrated Communication Switching System
ID	Identification
IDRP	Inter Domain Routing Protocol
IRD	Interface Requirements Document
ITU	International Telecommunications Unit
JRC	Joint Resources Council
kbps	kilobits per second
KHz	Kilohertz
LAN	Local Area Network
LBAC	Logical Burst Access Channel
LDRCL	Low Density Radio Control Link
LME	Link Management Entity
LMMC	Local Maintenance, Monitoring, and Control
LPA	Linear Power Amplifier
LRU	Lowest Replaceable Unit
M	Main
M/S	Main/Standby
MAC	Media Access Control
MASPS	Minimum Aviation System Performance Standards
MDR	Multimode Digital Radio
MDT	Maintenance Data Terminal
MHz	Megahertz
MMC	Maintenance, Monitoring, and Control
MNS	Mission Need Statement
MOPS	Minimum Operational Performance Standards

MTBF	Mean Time Between Failures
MTTR	Mean Time to Restore
NA	Not Applicable
NAILS	National Airspace Integrated Logistics Support
NAS	National Airspace System
NASPAS	National Airspace System Performance Analysis System
NDI	Non-Developmental Item
NEXCOM	Next Generation Air/Ground Communications
NIMS	NAS Infrastructure Management System
NOTAM	Notice to Airmen
OT&E	Operational Test and Evaluation
PCB	Polychlorinated Bi-Phenol
PCM	Pulse Code Modulation
PDC	Pre-departure Clearance
PKI	Public Key Infrastructure
POST	Power On Self Test
PT	Product Team
PTT	Push-to-Talk
RAPCON	Radar Approach Control
RATCF	Radar Air Traffic Control Facility
RCAG	Remote Control Air/Ground Facility
RCE	Radio Control Equipment
RCF	Remote Communications Facility
RCL	Radio Communications Link
RCO	Remote Communications Outlet
RD	Requirements Document
RDVS	Rapid Deployment Voice Switch
RF	Radio Frequency
RFI	Radio Frequency Interference
RIU	Radio Interface Unit
RMA	Reliability, Maintainability, and Availability
RMM	Remote Maintenance Monitoring
RMMC	Remote Maintenance Monitoring and Control
RMMS	Remote Maintenance Monitoring System
R-RCE	Remote - Radio Control Equipment
RTCA	RTCA, Inc. (formerly Radio Technical Commission for Aeronautics)
RTR	Remote Transmitter/Receiver
RU	Rack Unit
Rx	Receive
S	Standby
SARPs	Standards and Recommended Practices

SRD	System Requirements Document
SSS	Subsystem Specification
STR	Separated Transmitter/Receiver
STVS	Small Tower Voice Switch
T/R	Transmitter/Receiver
T&E	Test & Evaluation
TDLS	Tower Data Link Service
TDMA	Time Division Multiple Access
TE	Throughput Efficiency
TOA	Time Of Arrival
TOC	Transfer of Communication
TRACON	Terminal Radar Approach Control
TSGR	Transport Systems Generic Requirements
Tx	Transmit
Tx/Rx	Transmit/Receive or Transmitter/Receiver
UHF	Ultra High Frequency
USAF	United States Air Force
V	Volts
V/D	Voice/Data
VDL	VHF Digital Link
VEARS	VSCS Emergency Access Radio System
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
VSCE	Voice Switching and Control Equipment
VSCS	Voice Switching and Control System
VTABS	VSCS Training and Backup System
XID	Exchange Identifier (frame)
XPLP	X.25 Packet Layer Protocol

APPENDIX A Current NAS A/G Configurations

A.1 Current System Architecture

The current A/G Communications System for ATC consists of voice-based networks that use DSB-AM radios and operate in the 117.975-137 Megahertz (MHz) VHF band for civil aircraft and the 225-400 MHz UHF band for military aircraft. The radios operate with the same frequency used for controller-to-pilot (uplink) and pilot-to-controller (downlink) transmissions in a simplex "push-to-talk" mode. There is a dedicated, non-interconnected radio network for each operational environment (en route, terminal, airport surface, and flight service). In the event of a control facility power loss, engine generators provide back-up power. In the event of equipment failure, A/G communications are provided Back-Up Emergency Communications (BUEC) in the Enroute, Emergency Communications System (ECS) in the Large TRACONS and portable transceivers in the smaller TRACONS and Air Traffic Control Towers (ATCT).

The current A/G communications system architecture is roughly the same for all operational environments. The specific equipment used in the A/G communications string can differ among the various facilities. Different control facility types have different voice switches, with each type of switch having a unique interface. There was three types of radio control equipment; Grim, Intelect, and CSTI RCE. All of the Grim and most of the Intelect equipment has been replaced by the CSTI RCE. The CSTI RCE was designed to emulate the 12 VDC interface of the Grim and the contact closure interface of the Intelect. The CSTI RCE has been modified to emulate the interface of the BUEC Priority module.

A.2 NAS Communications Facilities

The major components of the current system can be broadly divided as follows:

- Area Control Facility (ACF) equipment
- Remote Communications Facility (RCF) equipment
- Transport media

The ACFs are the control sites and RCFs are the associated remote A/G radio sites. Table A-1 summarizes specific facility relationships and radio configurations of the A/G communications facilities utilized in the NAS. The various configurations are discussed in section A.3.

TableA-1 ACF/RCF Relationships

ACF Type	RCF Type	Configuration
ARTCC/CERAP	RCAG	T/R, M/S, STR
	BUEC	T/R (Main only)
	Local	T/R, M/S, STR
ATCT	RTR*	T/R, M/S, STR
	Local	T/R, M/S, Emergency
TRACON/RAPCON	RTR*	T/R, M/S, STR
	Local	T/R, Emergency
AFSS/FSS	RCO	T/R, M/S, STR
	Local	T/R, M/S, Emergency

Note:
T/R = Transceiver configuration
M/S = Main/Standby (Transmitter or Receiver) configuration
STR = Separate Transmitter Receiver sites
RTR = Remote Transmitter Receiver (a.k.a. as RT (remote transmitter site) if it only contains transmitters or as a RR (remote receiver site) if it only contains receivers.)
RCO = Radio Communications Outlet
AFSS = Automated Flight Service Station
TRACON = Terminal Radar Approach Control Facility
CERAP = Combined Center Radar Approach Control
Emergency = Emergency Transceivers (e.g., PET-2000)

A.2.1 Area Control Facilities (ACF)

Figure A-1 provides a general concept of the interrelationships between the various ACFs within the NAS. The three types of FAA control facilities (En Route, terminal, and flight services) include respectively ARTCCs and Combined Center Radar Approach Control (CERAPs), ATCTs and TRACONs/RAPCONs, and AFSS/FSSs. A control facility may have a collocated RCF. Most facilities use separate RCFs, but some RCF locations may be shared by different ACFs.

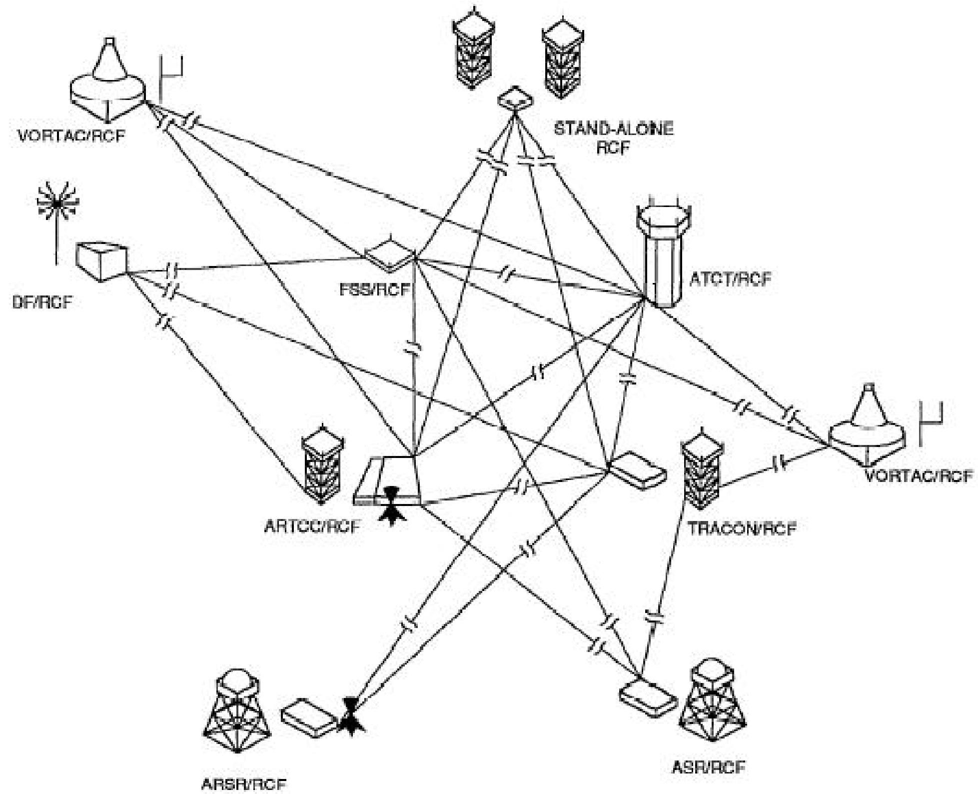


Figure A-1. ACF to RCF Diagram

A.2.1.1 ARTCC and CERAP

ARTCCs and CERAPs are responsible for en route air traffic control for all civil and military aviation. Each ARTCC has well defined airspace boundaries and is responsible for all airspace within these boundaries that has not been delegated to terminal ATC facilities. Each ARTCC and CERAP has RCAG and BUEC (planned for CERAPs) remote radio facilities to support en route A/G communications. Also, local RCAGs and BUECs are installed in the ARTCCs and CERAPs. Figure A-2 illustrates the current en route A/G communications system.

Depending upon channel configuration, RCAGs may have a paired set of VHF/UHF radios that allow the air traffic controllers to simulcast over VHF and UHF frequencies to control both civilian and military aircraft. After the BUEC expansion program is concluded, a pair of remote sites per sector, one RCAG and one BUEC site, will provide adequate support for approximately 75 to 80% of the currently defined en route sectors and the remaining 20 to 25% is provided through diversity sites. The local RCAGs and BUECs provide the close-in coverage in the vicinity of the ARTCC and CERAP.

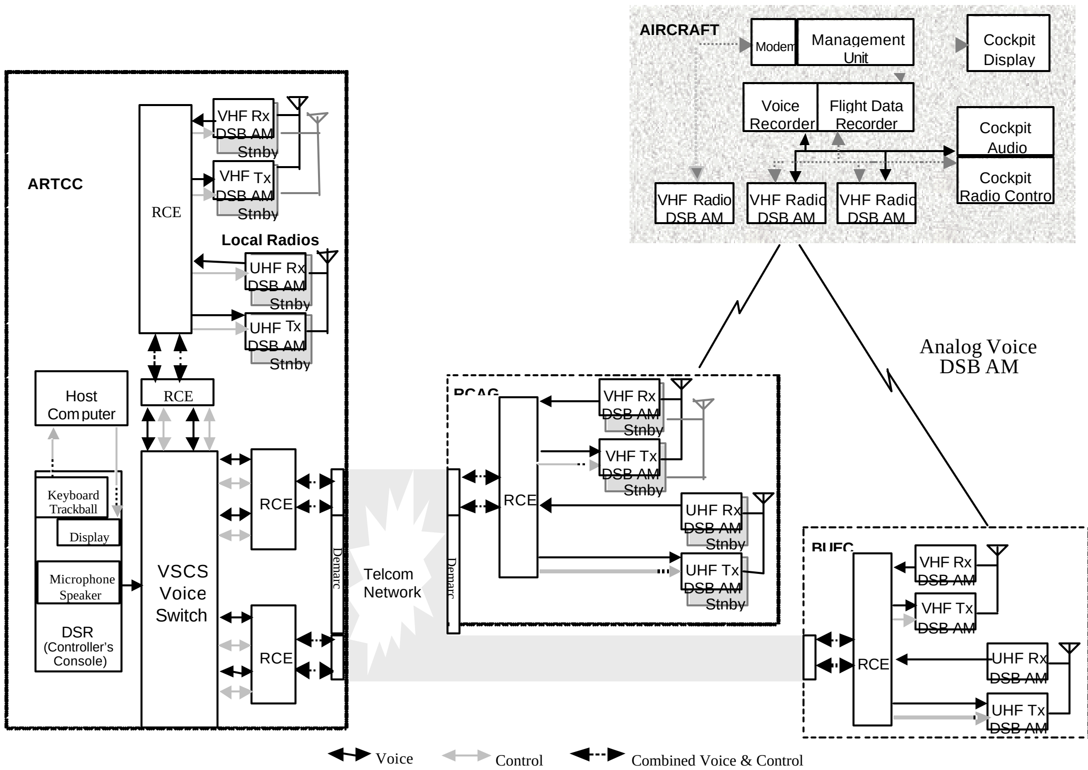


Figure A-2. Current En Route A/G Communications System

An ARTCC also can support a multi-RCAG site grouping commonly referred to as a Diversity Site Group. A diversity site group (reference to Section A.3.2.2) is used to extend A/G communications coverage for a controller of a large sector. In this configuration, there can be two to six RCAGs, each with its own BUEC, providing A/G communications support for that sector on one frequency (or frequency pair VHF/UHF).

The VSCS Training and Backup System (VTABS) can provide backup capability for a limited number of positions.

A.2.1.1.1 Controller's Display Console

The controller's display console provides the human interface for the voice switch, including the PTT switch, microphone, radio selection switches, and radar display of the airspace for which the controller is responsible.

A.2.1.1.2 Voice Switch

The voice switch provides the ability to control the connectivity of both A/G and G/G voice circuits. It may also include additional logic control functions associated with these circuits to maintain priority for controller shared remote sites or to interpret for an ARTCC controller the selection of old BUEC transceiver equipment that does not use RCE. Each ARTCC utilizes a VSCS to interface with all of its RCAG and BUEC sites. Voice signals to RCAGs are routed by the voice switch to a control site RCE that is connected to its remote site RCE counterpart through a dedicated telecommunications transmission system. The electrical interface to the VSCS for each of these facilities is contained in the VSCS ICD, NAS-IC-41024201. The major functions of the voice switch are:

- Interpretation and processing of controller commands.
- Selection of voice circuit/connectivity.
- Circuit/system status indication.
- Switching between input and output paths.

A.2.1.1.3 Control Site RCE (C-RCE)

The major functions of the C-RCE units are:

- Provision of VHF/UHF paired frequency operation (capable of independent selection of main, standby, transmit and receive operations)
- Reception of audio inputs via RCE-Voice Switch interface
- Transfer of remote radio control signals (e.g., push-to-talk, main/standby transmit/receive selection) from controller to remote site
- Provision of control and audio routing through RCE-Radio interfaces for both VHF and UHF main/standby transmitters and receivers.
- Allow flexible control of the audio and signaling routing via remote means

The C-RCE can emulate three legacy interfaces, if required, for voice switches and used in the NAS to connect to an RCAG or sustaining BUEC (S-BUEC) site. Those legacy interfaces are a +12 VDC interface (i.e. Grim) and a contact closure interface (i.e., Intelect 5134C). For a complete description of these two interfaces refer to the VSCS ICD (NAS-IC-42014000) and the RCE specification (FAA-E-2885).

The BUEC interface is unique and originally interfaced with the old BUEC transceiver system. Today the BUEC interface is emulated by the VSCS to interface to an old BUEC Priority Module or RCE. For a complete description of the older BUEC interface refer to the VSCS ICD (NAS-IC-64024201).

Some CERAPs now utilize RCE to provide the control interface to local radios and to BUEC sites. Without RCE, local radios typically were keyed via +24 VDC or a ground loop (contact closure). Figure A-3 depicts a previously used typical Local Radio implementation without RCE.

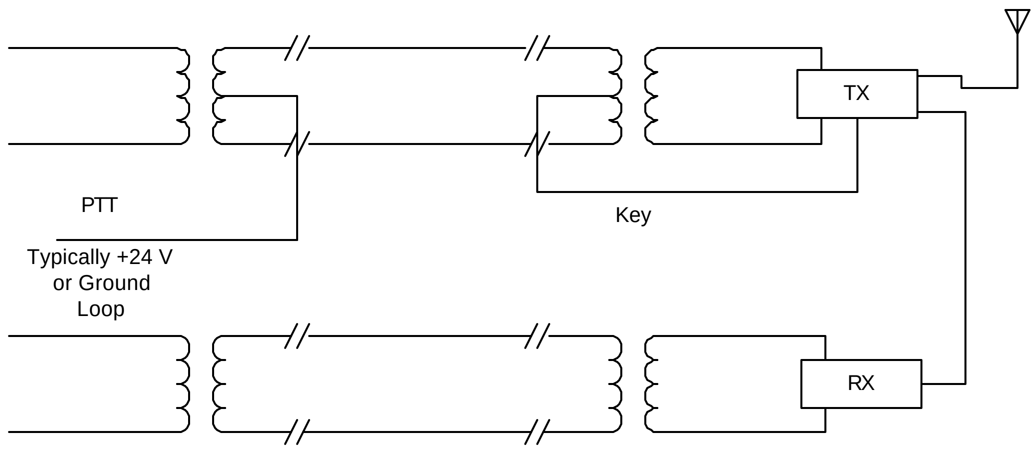


Figure A-3. Local Radio

A.2.1.2 Airport Traffic Control Tower (ATCT)

Tower air traffic controllers authorize aircraft movements including takeoffs, landings, and airport area movements, regardless of flight plans or weather conditions. The current FAA A/G Communications System also provides limited support for two-way A/G data communications by providing Pre-departure Clearance (PDC) and Digital Air Traffic Information Service (D-ATIS) messaging at 57 airports via the Tower Data Link Service (TDLS) using ARINC's Aircraft Communications Addressing and Reporting System (ACARS) network. A/G communications are normally via RTR A/G radio facilities, but also may involve voice broadcast on other facility transmitters. The Voice Switch Bypass (VSBP) can provide the backup capability for a limited number of frequencies at a limited number of positions.

A.2.1.3 Terminal Radar Approach Control (TRACON)

TRACON controllers use radar/Beacon and computer capabilities to provide approach control services to aircraft arriving, departing, or transiting airspace controlled by that particular facility. Similar facilities are the U.S. Air Force (USAF)/FAA Radar Approach Control (RAPCON) facilities and the U.S. Navy Radar Air Traffic Control Facilities (RATCFs). A/G communications are usually via the terminal A/G radio RTR facilities shared with the local ATCT. The Voice Switch Bypass (VSBP) can provide backup capability for a limited number of frequencies at a limited number of positions.

A.2.1.4 Automated Flight Service Station (AFSS)/Flight Service Station (FSS)

The AFSS is a computerized central operations facility that combines and automates the functions of two or more FSSs at a single location. The AFSS provides automated data acquisition and transmission capability for centralized flight plan processing; weather information consolidation and dissemination; Notice to Airman (NOTAM) services; pilot briefings; and other en route, terminal and airport advisory services. A/G communications from an AFSS are via RCO A/G radio facilities.

A.2.2 Remote Communications Facilities (RCF)

There are four different types of RCF facilities; RCAG and BUEC for ARTCC support, Emergency Communications System (ECS) for TRACON support, RTR for ATCT and TRACON support, and RCO for AFSS support. Figure A-4 defines the designated type of RCF associated with each control facility. (See Table A-1)

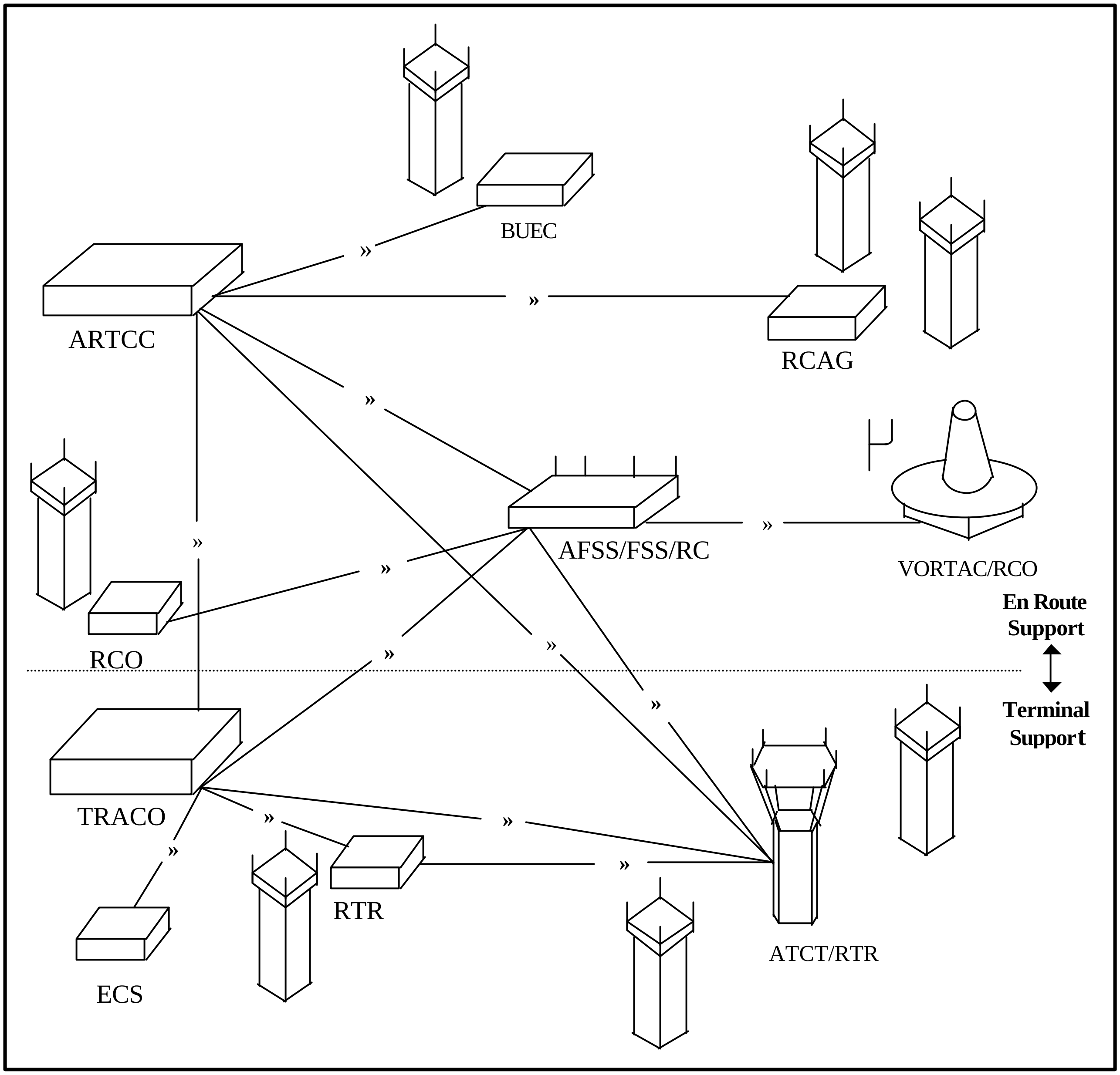


Figure A-4. Typical RCF Types For Specific Control Facilities

Note: An RCF may be collocated with its control facility or with another facility, on a non-interference basis, and in some cases, a single RCF may serve more than one type of control facility.

A.2.2.1 Remote Communications Air/Ground Facility (RCAG)

An RCAG is typically an unmanned remote A/G radio facility that expands A/G communications coverage for an ARTCC and provides direct radio contact between pilots and controllers. RCAGs typically are located remote from the ARTCC. Depending on the sector being provided coverage, an RCAG could be on top of a mountain, in the middle of the desert, or near a large metropolitan area. Each RCAG contains redundant VHF and UHF transmitters and receivers and one CSTI RCE for each operational VHF/UHF frequency pair. VHF and UHF radio equipment usually paired to share the same voice channel, control signaling on a common line and radio control equipment required to demodulate radio control signals to transfer equipment between main and standby.

A.2.2.2 Back Up Emergency Communications (BUEC) Facility

A BUEC facility provides a one-for-one channel backup for an RCAG facility. BUEC channels purposely use independent transmission paths from the ARTCC with respect to its matching RCAG channel. The BUEC system's redundant VHF and UHF communication channels are selectable by the ARTCC controller for immediate use whether or not any primary RCAG frequency fails. BUEC facilities provide only main transmitters and receivers, not standby transmitters and receivers. BUEC radios are typically configured the same as an RCAG in a TX/RX configuration. Older tunable DSB-AM transceivers are still in use in some BUEC sites; however, there is an ongoing BUEC improvement program that will replace the existing transceivers with separate transmitters, receivers, and RCE. Also, BUEC facility power sources and lines are totally separate from the corresponding services provided to the RCAG facility handling the primary A/G communications. BUEC facilities may be collocated with various NAS facilities such as RCAGs (not same frequency as BUEC), RTRs, RCOs, RCL sites, LDRCL sites, VHF Omni-directional Range (VOR)/distance measuring equipment (DME), VORTAC, or ILS sites, but collocation at radar sites is discouraged due to EMI.

A.2.2.3 Remote Transmitter/Receiver (RTR)

RTR facilities provide pilot and controller voice communications in the TRACON and ATCT areas. Civil/military joint use areas must have both VHF and UHF equipment installed. RTR facilities in less congested areas may house equipment used for other than terminal ATC, e.g., BUEC, RCAG and RCO functions. Control, voice, and data circuits to these facilities may be FAA-owned and maintained. RTR facilities have several different configurations, depending on the needs for the terminal area. The transmitters and receivers may be located at separate sites and/or the main and standby equipment may be at separate sites. *Note: If the RTR contains only transmitters or receivers it is known as an RT (remote transmitter) or RR (remote receiver) site*. However, each RTR VHF or UHF channel will consist of four radios, two transmitters (M/S) and two receivers (M/S). RTR sites are typically located on the airport, however some RTR sites may be located several miles from the airport in order to achieve necessary coverage/diversity for the supporting TRACON/ATCT. Figure A-5 shows a typical RTR site configuration for an airport.

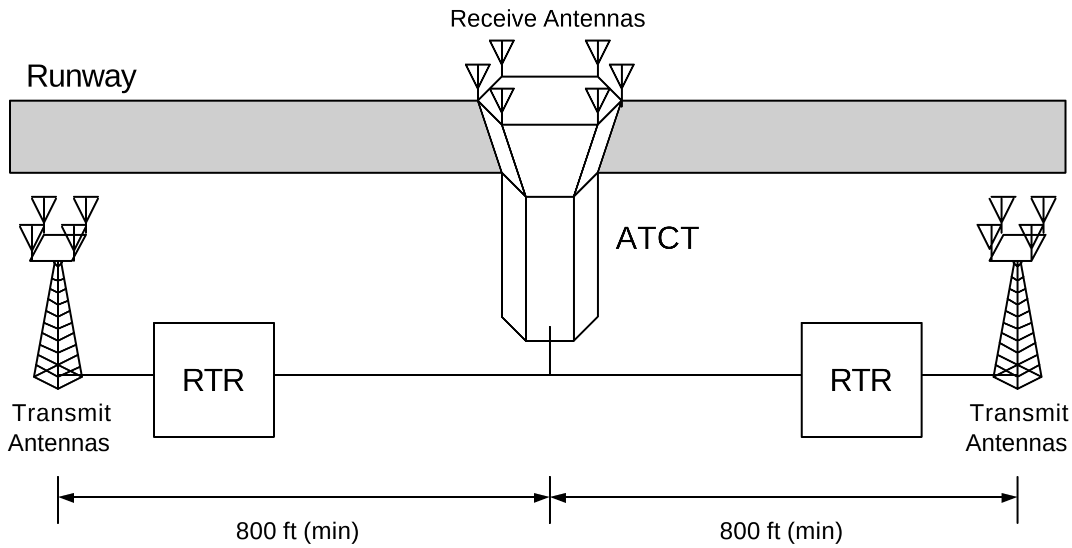


Figure A-5. Typical RTR Site Configuration

A.2.2.4 Remote Communications Outlet (RCO)

RCOs are remote A/G radio communications facilities that provide A/G links between AFSS/FSS specialists and pilots flying in FSS flight advisory areas. RCOs typically are collocated with other FAA facilities such as RCAGs, BUEC, RTRs and VOR facilities. VOR collocated RCOs may use their voice transmitter capability as the FSS link to pilots with the receiver link located at the same site. Typical RCO facilities contain VHF transmitters and receivers (M/S) and some UHF transmitters and receivers (M/S).

A.2.2.5 ECS Equipment

Currently, ECS equipment consists of remote site RCE units, analog transmitters, receivers, power systems, cable, antennas, and where required to reduce EMI, transmitter combiners and receiver multicouplers.

A.2.2.6 RCF Equipment

Currently, RCF equipment consists of remote site RCE units, analog transmitter, receivers, power systems, cable, antennas, and where required to reduce EMI, transmitter combiners and receiver multicouplers.

A.2.2.7 Remote Site RCE (R-RCE)

The CSTI R-RCE unit receives combined audio and control signals from the control site via a telecommunications (terrestrial, microwave, or satellite) medium. The interface is designed for an analog 4-wire voice circuit. The R-RCE separates the control signals from the audio before delivering them to the radio interface. The R-RCE also receives downlink audio signals from the A/G radio interface and puts them into a format suitable for transmission back over the analog 4-wire voice circuit. RCE supplies the proper electrical characteristics to interface to that circuit.

A.2.2.7.1 A/G Radios

At primary A/G radio remote sites there are eight radio units associated with a voice channel. This includes main and standby units for transmitters and receivers operating in both the VHF and UHF bands.

All radios are interfaced to the remote site RCE units and either directly to site antennas or to antenna transfer relays. Currently, radios used for main and standby communications are fix-tuned analog radios. Because of fixed-tuned cavity filters within the radios, adjustment of frequencies requires on site technician to perform the retuning of the cavity filters or swapping out radios for replacement by radios with cavity filters pre-tuned to the new frequencies desired.

A.2.2.7.2 Transmitters

Transmitters receive audio and push-to-talk signals from the remote site RCE and generate modulated RF signals that are provided to the antenna. Output power is typically 10 watts, but some transmitters use a 50-watt linear power amplifier (LPA) for extended range. Multiple transmitters may be connected to a transmitter combiner for output to the antenna at remote facilities where co site interference problems exist or to reduce costs on antennas/towers where many operational frequencies are in use.

A.2.2.7.3 Receivers

Receivers accept modulated RF signals from an antenna and amplify, down-convert, and demodulate the signals to supply audio to the remote site RCE. Multiple receivers also may be connected to a receiver multicoupler to reduce costs on antennas/towers where many operational frequencies are in use.

A.2.2.7.4 Antennas

A transmitter and receiver pair may be connected to one or more antennas, depending on the desired configuration. Main and standby radios are frequently connected to separate antennas for diversity. An external antenna transfer relay or internal transmitter relay is used to switch between separate transmitters and receivers operating with a common antenna. At many sites, antennas providing diversity are separated to provide transmit/receive isolation. Some sites utilize 4 dBi omni-direction and 10 to 12 dBi directional antennas.

A.2.3 Telecommunications Media

The Control and Remote site RCE's interface through the telecommunications media, which could be landlines (analog or digital, leased or owned), microwave, fiber optics, or satellite links. The supplied media could also employ two or more of the above-mentioned services. The present communications path being provided for radio circuits is a Voice Grade 6 with no monitoring tone provided in FAA Order 6000.22. Many of the communications paths are also provided by the FAA's RCL and LDRCL infrastructure. Satellite communications (FAATSAT and ANICS), also provides service in some difficult access areas. When backup sites are used, the FAA has a diversity plan that it implements and will make every attempt to keep the primary and backup services on separate/different telecommunications media. When this is not possible the supplied services provided to the primary and backup radios will not share the same Central Office thus providing diversity paths. FAA owned fiber and cable are usually the media used at the facilities located on or around the airports being serviced.

A.3 RCF Radio Configurations

The following subsections describe typical RCF radio configurations and typical ACF/RCF control configurations.

A.3.1 RCF Tx/Rx Configurations

An RCF may have one Tx/Rx configuration or a combination of Tx/Rx configurations. The following sections describe the various transmitter and receiver configurations/locations that are utilized at the majority of the RCF facilities in the NAS today.

A.3.1.1 Transmit/Receive (T/R)

In the T/R configuration, the transmitter and receiver pair are connected to the same antenna via an antenna transfer relay located in the transmitter. When an LPA is added, an external Antenna Transfer Relay may be utilized in place of the transmitter's internal relay. This configuration is typical in many RCAGs, BUECs, RCOs, and some RTRs. Figure A-6 depicts a simplified view of the T/R configuration. Figure A-7 depicts one possible site configuration for groups of T/R antennas.

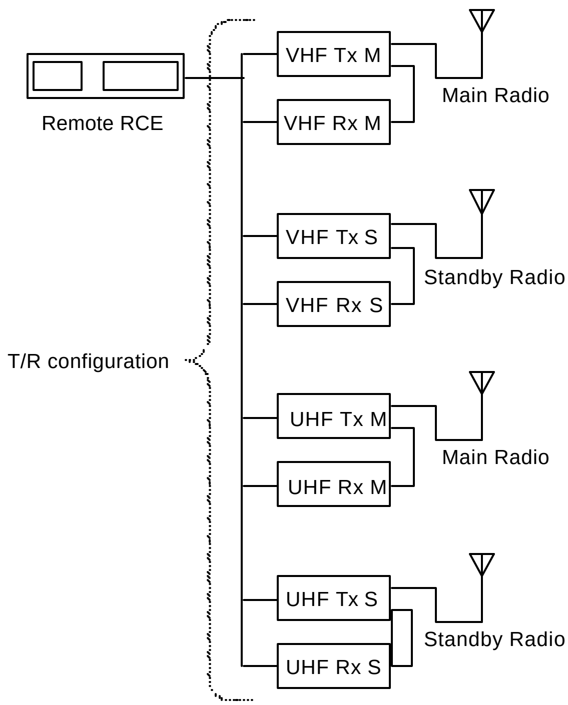


Figure A-6. T/R Configuration

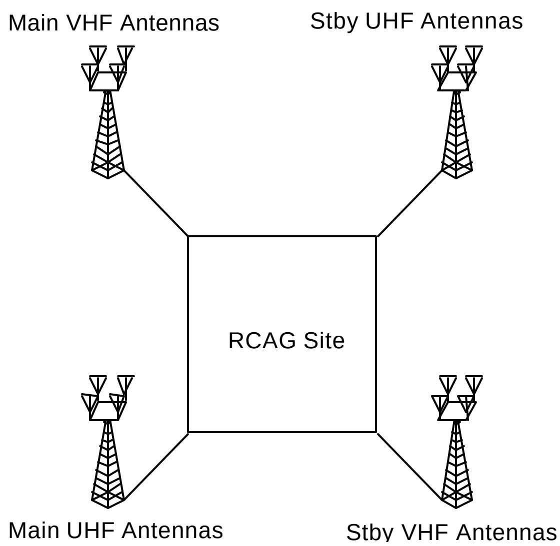


Figure A-7. Site Diagram for T/R Configuration Antenna Groups

A.3.1.2 Main/Standby (M/S)

In the M/S configuration, the antenna is typically connected to an external Antenna Transfer Relay (ATR). The main transmitter and the standby transmitter are then connected to the antenna transfer relay (similarly for the receivers). In some cases, the main transmitter's internal antenna relay is used instead of the external ATR. The M/S receivers may also be connected in series so that input from the antenna is present at both receivers. Figure A-8 depicts a simplified view of the typical M/S configuration. Figure A-9 depicts a typical site configuration for the M/S connected antennas.

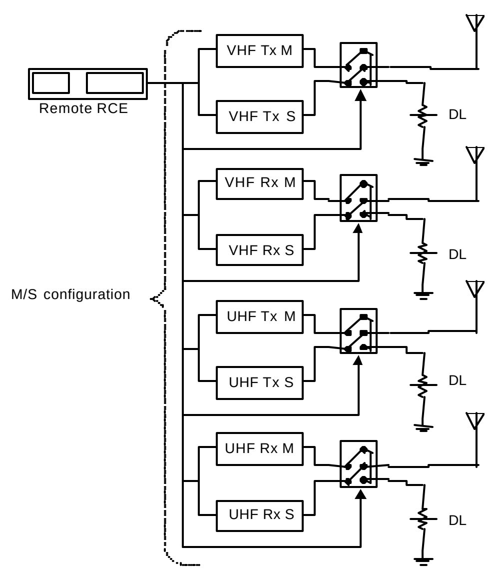


Figure A-8. Diagram for Radios in M/S Configuration

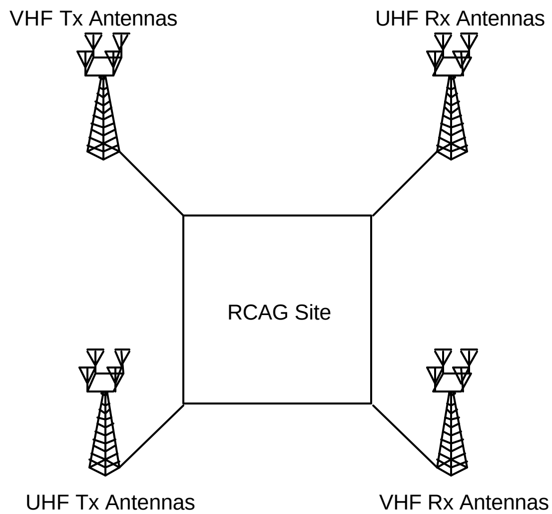


Figure A-9. Antenna Site Diagram for the M/S Radio Configuration

A.3.1.3 Separate Transmitter/Receiver (STR)

In the separate Tx/Rx configuration (STR), some antennas are connected to a transmitter combiner or a receiver multicoupler and then connected to several transmitters or receivers respectively. The transmitters and receivers may be collocated in the same facility or may be located in separate facilities. Figure A-10 depicts a simplified view of the STR configuration. Figure A-10a depicts the typical STR configuration. Figure A-11 depicts a typical site configuration of the antennas.

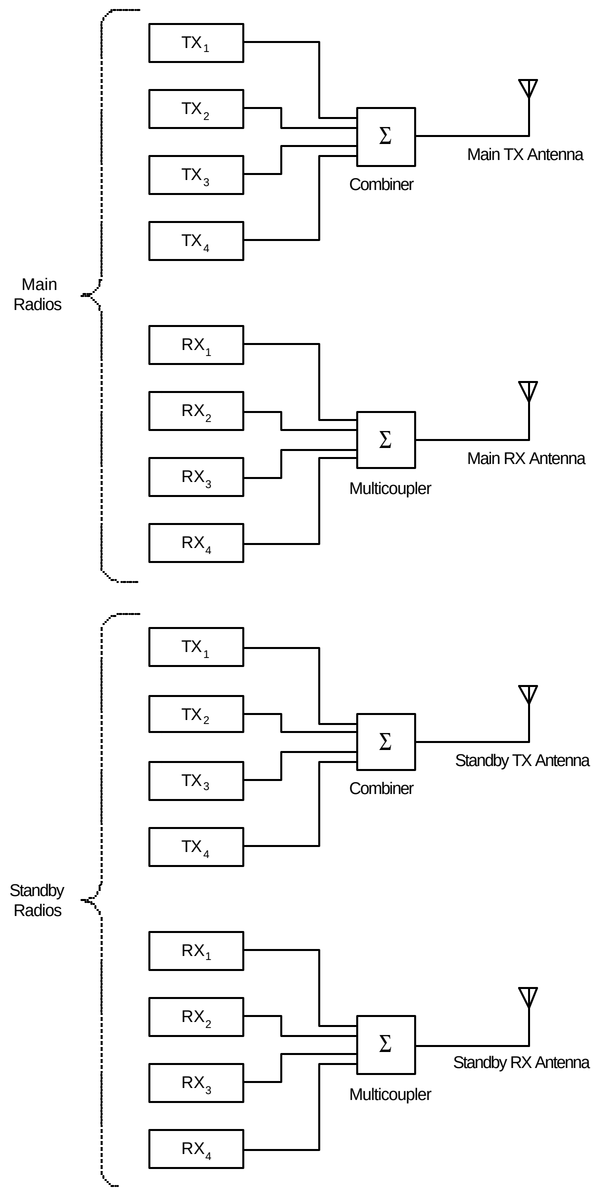


Figure A-10. STR Configurations Using Combiners/Multicouplers

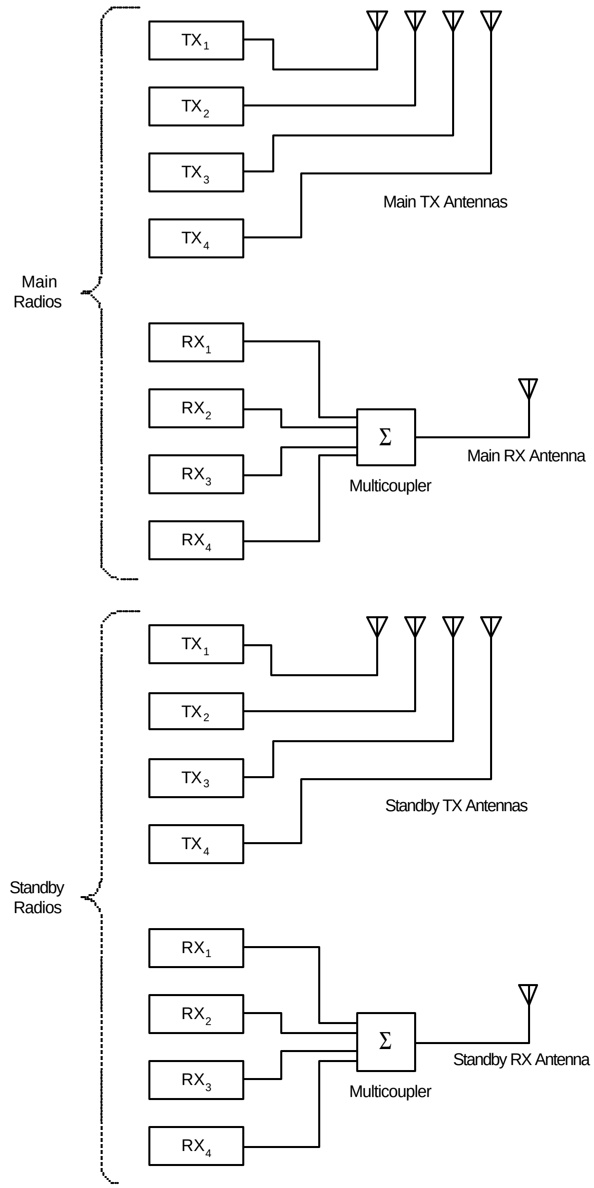


Figure A-10a. Typical STR Configurations Using Only Multicouplers

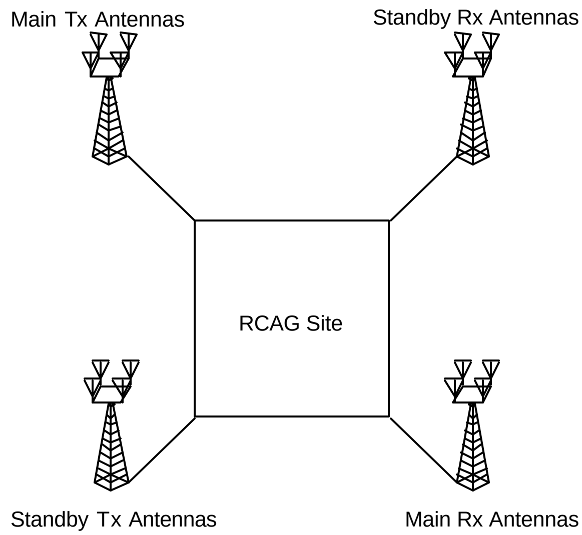


Figure A-11. Site Diagram for STR Antenna Configuration

A.3.2 RCF Control Configurations

For each RCF channel, there are different control possibilities. The standard is for one ACF to control each remote VHF/UHF channel or frequency. The following sections discuss the other two most prevalent control configurations.

A.3.2.1 RCE Dual Control

A dual control configuration exists between two ACFs and one RCF channel. As indicated in Figures A-12 and A-13, the RCE provides the capability to allow two control facilities to utilize a single remote VHF/UHF channel or a single frequency. A typical application for dual control is where a tower will be manned and operated during normal business hours and then be turned over to another ACF that is manned 24 hours a day. The RCE provides for both a non-priority and priority mode of simultaneous control. Refer to the RCE specification, FAA-E-2885, for more details of RCE dual control mode.

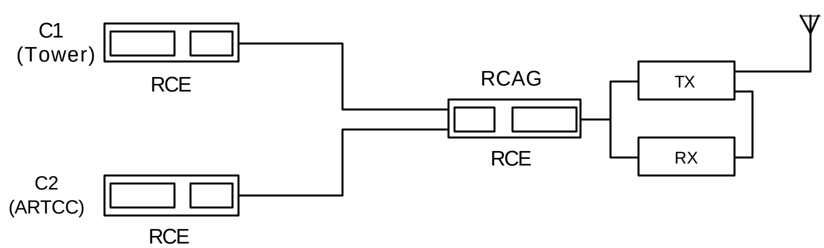


Figure A-12. Dual Control Using RCE

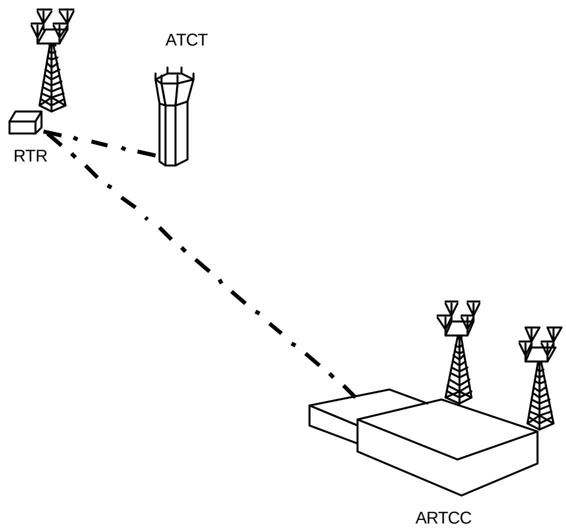
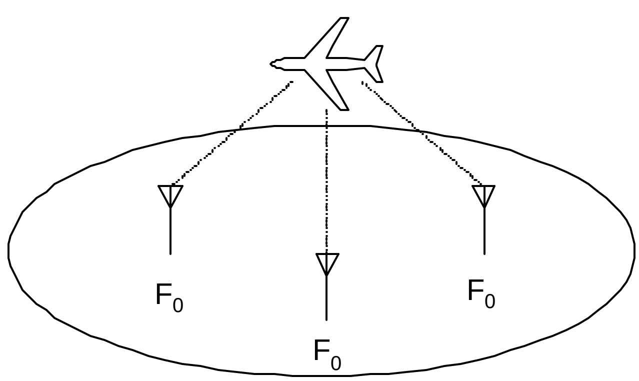


Figure A-13. Dual Control Site Diagram

A.3.2.2 Diversity Site Groups

The VSCS supports a multi-RCAG/BUEC site grouping commonly referred to as a Diversity Site Group. In this configuration there can be from 2 to 6 RCAG facilities (and their associated BUEC facilities) providing A/G communications support on the same operating frequency for one large sector. In some cases, this is implemented using multiple frequencies. The diversity site group allows an operator the ability to simultaneously operate from the selected Tx/Rx pair and listen on up to 6 radio receivers on the same frequency. The VSCS only allows one transmitter to be keyed at a time, which is determined by operator selection. All receivers can be active at the same time with VSCS utilizing a somewhat First In First Out (FIFO) approach to selecting the first received acceptable level audio from the receivers and presenting it to the operator's headset for use. Figure A-14, illustrates the diversity site group concept.



Multiple sites on same frequency in same sector.

Figure A-14. Diversity Site Group

APPENDIX B NEXCOM System Architecture

B.1 Introduction

The A/G Communication System is required by the FAA to support services that ensure aircraft separation, transmit instructions and clearances, permit hand-offs, provide weather information and pilot reports, and communicate with AFSS/FSSs. Different subsets of these services are required to support different phases of flight, including ground movements on the airport surfaces and in gate areas; departures and arrivals in the terminal area; and the en route phase of flight. The NEXCOM System is the next generation A/G communications system that implements VDL Mode 3 standards and provides integrated voice and data services, and other operational enhancements over the current analog voice only system. This section describes the VDL Mode 3-based NEXCOM System architectures to include the sustainment system and the end-state system.

B.2 NEXCOM Services

The NEXCOM System provides the following services:

- Voice
- Point-to-point data
- Uplink data broadcast.

B.3 NEXCOM System Description

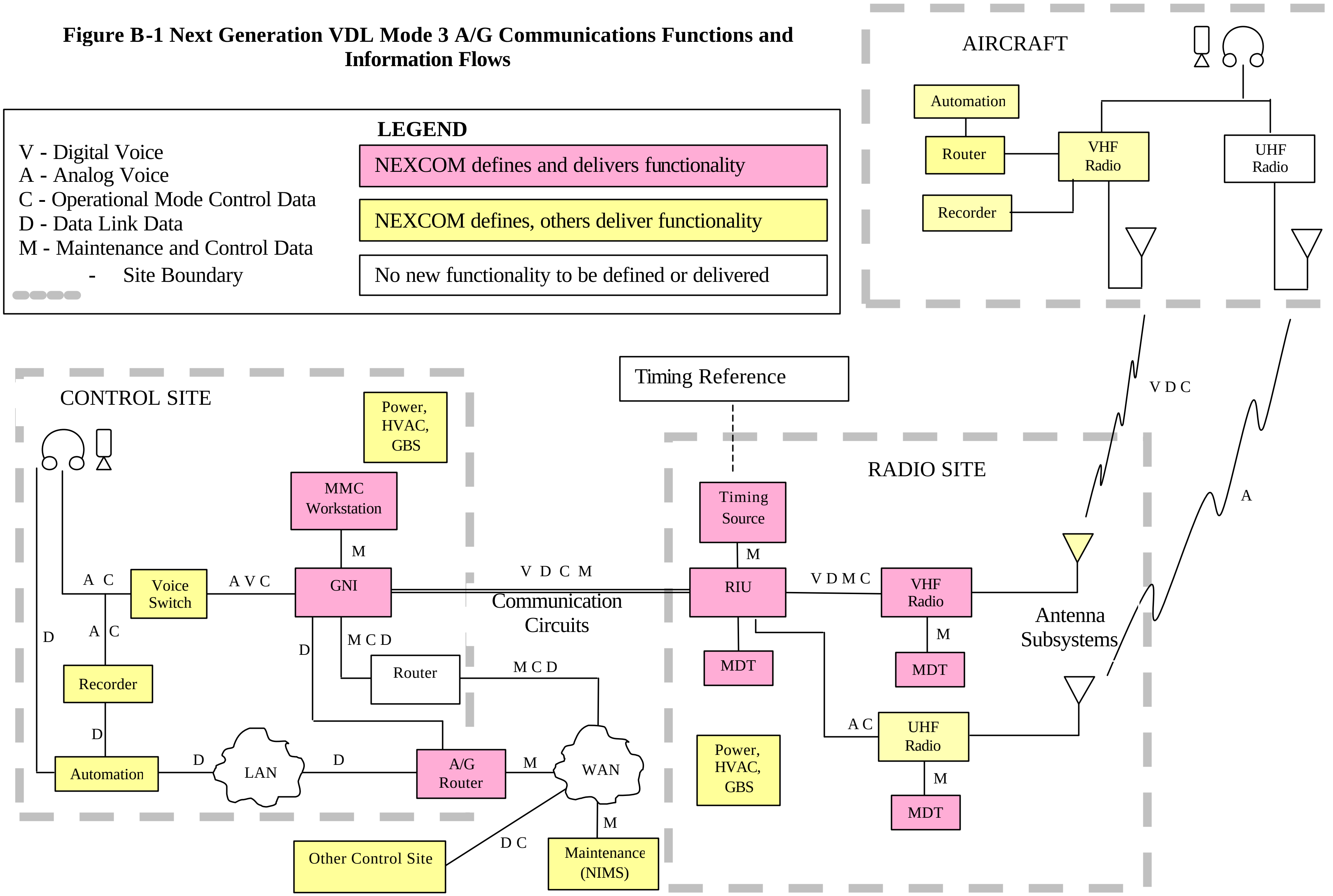
Figure B-1 is a simplified block diagram of the next generation A/G communications system, illustrating the key functional blocks of the A/G communications system in the NEXCOM end state. Figure B-1 identifies three types of functional blocks and how they are interconnected:

- NEXCOM defined and delivered elements,
- legacy system elements where enhancements or modified functionality are expected, and
- legacy system elements that are not impacted by NEXCOM.

The NEXCOM defined and delivered functionality is defined in this SRD to include the following subsystems:

- MDR
- RIU
- GNI
- A/G Router
- External Timing Source
- MDT Software Element
- MMC Workstation

Figure B-1 Next Generation VDL Mode 3 A/G Communications Functions and Information Flows



Legacy system elements where enhancements or modified functionality are expected include the following elements:

- VSCE
- Automation
- Recorder
- NIMS
- UHF Radio
- Power, HVAC, and GBS
- Telecommunications Links

The enhancements and modified functionality represent requirements imposed on the legacy equipment by the NEXCOM System.

Legacy elements that are not expected to be affected by NEXCOM include general networking elements, such as LAN and WAN, and the antenna subsystems.

The NEXCOM Subsystems are briefly described in the following subsections.

B.3.1 MDR

The MDR subsystem is the FAA VHF ground radio element of the NEXCOM System. It is a multi-mode radio providing selectable operating modes of 25 kHz DSB-AM, 8.33 kHz DSB-AM, and VDL Mode 3. The MDR subsystem is specified to be a direct replacement for the current generation 25 kHz DSB-AM radios with the purpose of sustaining the current DSB-AM A/G communications ground system infrastructure. The MDR subsystem implements the physical layer, the MAC sublayer processing functions of VDL Mode 3, and other radio and modulation functions. The MDR will be implemented as a separate MDR transmitter and MDR receiver.

In sustainment, the MDR subsystem will operate in 25 kHz DSB-AM mode and continue to interface to the legacy RCE and antenna subsystems. The MDR in conjunction with the other NEXCOM Subsystems and other A/G communications elements will operate in VDL Mode 3 to deliver the NEXCOM integrated voice and data services. The inclusion of the 8.33 kHz DSB-AM capability in the MDR subsystem is for risk mitigation.

To provide maximum operational flexibility, a high power version of the MDR transmitter will be procured in addition to the normal (low) power MDR transmitter. The high power transmitter will be used for any sectors to extend the coverage range to beyond 200 nmi.

B.3.2 RIU

The RIU subsystem provides most of the DLS and MAC protocol functions of the VDL Mode 3, voice encoding/decoding, MDR and UHF radio control, and acts as a RMMC agent for the MDR radios and the next generation UHF radios. Each RIU is implemented to be capable of supporting all VDL Mode 3 system configurations associated with a single 25 kHz channel assignment.

The RIU schedules all uplink and downlink data transmission over the available data slots by implementing a centralized data reservation scheme, which is based on its uplink data transmission needs, message priority, and downlink reservation requests. A possible data channel reservation algorithm is described in ICAO Doc X (Manual for VDL Mode 3 Implementation).

The RIU subsystem must support simultaneous integrated digital voice and data operation in VHF and analog voice operation in UHF. For this reason the RIU includes VDL Mode 3 standard vocoders to perform conversions between analog voice and digital voice for UHF operation in the NEXCOM end-state.

The RIU subsystem interfaces with the MDR subsystem and with the GNI subsystem located at a control facility via an interfacility communications link to provide VDL Mode 3 integrated voice and data services.

The RIU provides the timing reference for the VDL Mode 3 system. It derives system timing from an external timing source and provides system time clocks to MDR and GNI subsystems. It also controls the timing of the uplink Beacon transmissions of the MDR to provide timing reference for the aircraft radios.

B.3.3 GNI

The GNI subsystem provides both VDL Mode 3 voice processing and the subnetwork access protocol functions associated with transporting the VDL Mode 3 subnetwork packets. The GNI multiplexes digital voice, traffic data, and control and management data for transmission over the inter-facility communications links to its RIUs and de-multiplexes bit streams received from the RIUs into digital voice, traffic data, system management data, and MMC data. For voice processing, the GNI subsystem includes VDL Mode 3 vocoders that perform voice encoding/decoding and A/D and D/A conversions. For network functions, the GNI provides packet exchanges, header compression, subnetwork connection management functions, and link management functions, including error recovery, flow control, and packet fragmentation. Specifically, the following functions are performed:

- The GNI provides link management functions such as link parameter negotiation/modification (through XID exchanges with the aircraft), link redirection, and handoff for aircraft transitioning between sectors within the same center, and frame formatting.

- The GNI provides subnetwork management functions such as Join/Leave messages. Whenever an aircraft enters the control region of a GNI, the presence of the aircraft can be announced to any attached network routers via a Join Message. Similarly, when the aircraft is no longer available for data transfer, a Leave message can be sent to the attached network routers.

- The GNI subsystem performs specific ATN functions to support the ATN standards. The GNI receives data packets from the A/G Router and performs its own subnetwork header compression to improve link efficiency. The GNI system provides subnetwork interfaces for communicating ISO 8208 and CLNP packets with and without compression. The GNI supports both the Connectionless Network Protocol (CLNP) packets and connection-oriented ISO 8208 packets.

- The GNI subsystem also performs ground switching of data frames between GNIs in neighboring ARTCCs, as needed, to minimize any disruption in communication due to network protocol initialization of the ATN system (IDRP connection). This function is known as Make-before-Break (MbB).

For data service, the GNI interfaces with the A/G Router through a GNI Data Switch function. The GNI Data Switch functions as a switch, which reduces the workload and interface requirements of the A/G Router, necessitated by the large number of GNIs and a limited number of A/G Routers. The data switch function can be implemented as a physically separate entity or integrated with some of the GNIs or with the A/G Router. In the former a single GNI Data Switch function will be collocated with each A/G Router per ARTCC. In integrating GNI Data Switch Function with the ARTCC GNIs, the ATN data to and from a GNI located at the terminal environment will be routed through an ARTCC GNI to access the A/G Router collocated with the ARTCC GNI.

The GNI subsystem interfaces to the VSCE, the A/G Router, NIMS, MMC Workstation, and via inter-facility communications links to the RIU. The GNI interfaces through the A/G Router with the automation system to receive the next channel frequency information to uplink the Next Frequency message.

For MMC, the GNI provides concentration for all NEXCOM MMC data, serves as NIMS proxy agent for the RIU and MDR, provides an interface to NIMS for the NEXCOM System, and interfaces to the NEXCOM MMC Workstation.

B.3.4 A/G Router

The A/G Router provides routing to establish communications between any ground location, which has access to the router, and any ATN-equipped aircraft in the world. The A/G Router provides the intelligence to route data to any aircraft with the correct ICAO address, taking into account that the aircraft are mobile, more than one data link service (including VDL Mode 3) can be used for delivery, and multiple links or paths are available for making the connection. The A/G Router implements the Inter-Domain Routing Protocol (IDRP), which distributes the aircraft path information among the ATN backbone routers and is also used by the aircraft to inform the ground routers that it is available.

The A/G Routers are currently envisioned to be collocated at ARTCCs, one per ARTCC, to reduce the capacity impact of IDRP connection changes due to the restricted bandwidth available to the NEXCOM System. Terminal GNIs will have to be routed through a GNI Data Switch function at an ARTCC to have A/G Router access for ATN data service. Each A/G Router will provide the ATN subnetwork services to the GNI within its domain. The A/G Router provides and interfaces through the Subnetwork Dependent Convergence Function (SNDCF) to support the following

- the VDL Mode 3 8208 Packet Layer Protocol (PLP) compression
- the CLNP Frame Mode Compression
- ATN Frame Mode.

The A/G Router is connected to the HID NAS LAN to interface with the automation system.

B.3.5 External Timing Source

The proper operation of the NEXCOM System in VDL Mode 3 requires the VDL Mode 3 system timing to be synchronized among the different ground stations sharing the same frequency in a common geographic area. Global timing synchronization of all the ground sites within NAS is not required but is assumed since synchronization to a globally available common external timing reference is desirable and is readily available, e.g., GPS.

The VDL Mode 3 system interface to the external timing source is through the RIU. The RIU derives the system timing from the external timing source, which is kept stable through synchronization to a highly accurate external timing reference. The RIU provides system timing to the MDR by controlling the timing of the uplink Beacon transmission, which is broadcast to the aircraft users periodically and is used by the aircraft radios to maintain accurate timing control of all aircraft downlink transmission.

The MDRs are required to maintain their timing to within $\pm$ 10 µsec of the system reference timing established by the RIU. The external timing source includes a high stability oscillator that will maintain sufficient timing accuracy to sustain the system operation for a minimum of 30 days, in the event of an extended outage of the external timing reference.

B.3.6 MDT Software

The NEXCOM MDT software subsystem is NEXCOM specific software developed specifically to perform monitoring, maintenance, and control functions on the NEXCOM Subsystems locally and remotely. MDT access will be provided at the RIU and MDR. The NEXCOM MDT software will be installed in the standard NIMS MDT to include INFOSEC features as specified in this document to protect against unauthorized access to the NEXCOM MMC system.

B.3.7 MMC Workstation

The NEXCOM MMC Workstation is a dedicated workstation, which is permanently connected to the GNI to provide real time monitor, control, and MMC data processing capability to the NEXCOM System operator on the GNI and all connected RIUs, MDRs, and the next generation MMC-capable UHF radios. The A/G Router is envisioned to have its own separate MMC port and its own NIMS interface and will only interface with the NEXCOM MMC Workstation for status indication in case of a failure to the A/G Router. The NEXCOM MMC Workstation will also control the NIMS interface to configure the specific parameter set and MMC functions that will be made available to NIMS.

B.4 A/G Communications System Architecture

The A/G communications system is comprised of both ground and aircraft components. It is assumed that as the A/G communications system evolves from the current system architecture (See Appendix A) to the end-state NEXCOM architecture, the aircraft component will incorporate fully compatible and interoperable VDL Mode 3 avionics. With this in mind the discussion of the A/G communications system architecture below will focus on the ground component.

B.4.1 Sustainment System Architecture

To sustain the existing infrastructure and to facilitate the transition to NEXCOM, the transition strategy allows NEXCOM MDR transmitters and receivers, as available, to enter the analog A/G radio supply chain for both replacement and growth applications. However, the sustainment of the current A/G Communications System, while retaining the existing system architecture, does have implications on both transition activities and the NEXCOM System level requirements, particularly for the MDR subsystem.

For sustainment, MDR transmitters and receivers will be installed in existing racks using power, or other supporting infrastructure. The MDR units will include interfaces necessary to connect to the existing RCE. The MDR units will be compatible replacements for the existing analog VHF transmitters and receivers in RCAG, BUEC, RTR, RCO, and local radio installations and will operate in the 25 kHz DSB-AM mode. Figure B-2 illustrates the insertion of NEXCOM radios to sustain present A/G communications. The operation of the sustainment system will be identical to that of the current system and transparent to the users.

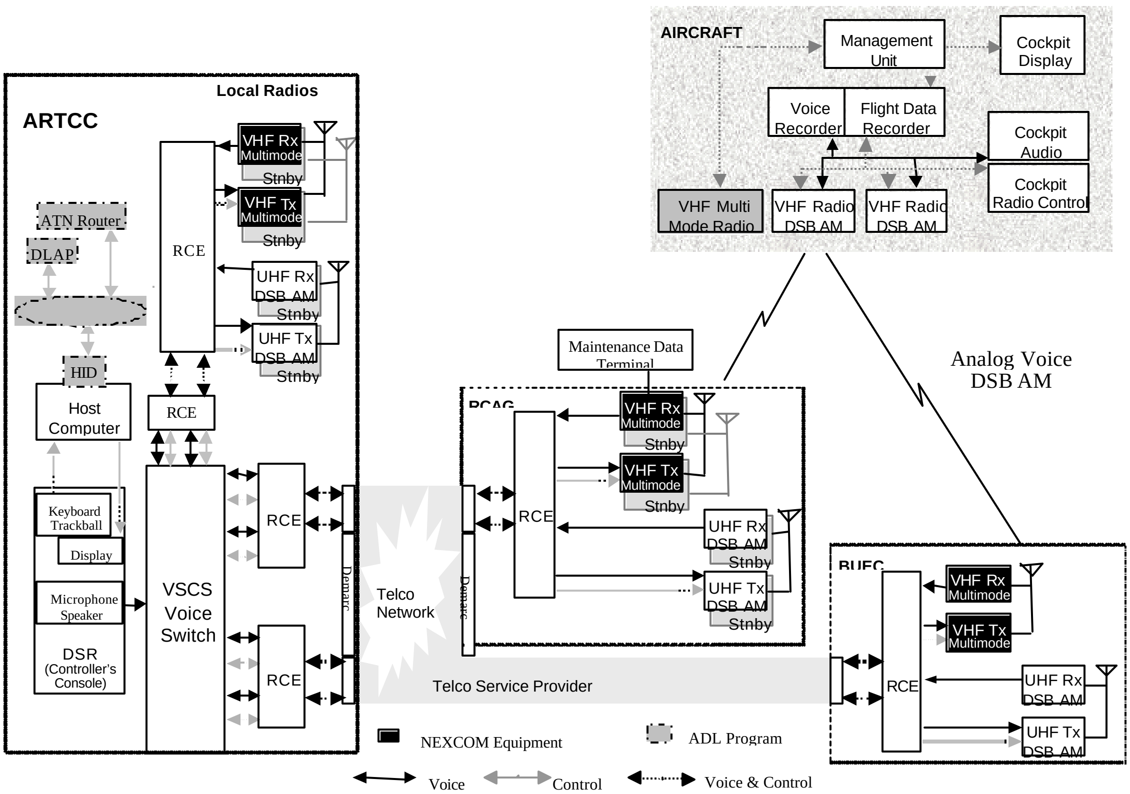


Figure B-2. Sustainment Architecture with NEXCOM MDRs (En Route)

B.4.2 NEXCOM End-State System Architecture

A functional block diagram illustrating the overall NEXCOM end-state system architecture is shown in Figure B-3 with the NEXCOM GNI, RIU, and MDR subsystems integrated with the legacy equipment for a typical en route sector. The NEXCOM end-state is configured to provide VDL Mode 3 integrated voice and data services or to provide VDL Mode 3 digital voice only services, depending upon the specific VDL Mode 3 system configurations chosen.

MDR transmitters and receivers will be installed in existing RCFs to replace the current VHF analog radios. RIUs will be installed to replace the existing RCEs to provide the critical VDL Mode 3 link layer functionality and to provide remote monitoring and control of the MDRs and the next generation UHF radios. The GNI will be installed at the control facility to perform voice encoding/decoding, multiplexing function, and network layer functions associated with Subnetwork Access Protocol (SNAcP) and the DLS functions complementary to that of the RIU.

The current voice-grade leased lines need to be upgraded with digital links of appropriate bandwidths and characteristics for most applications. For applications with lesser bandwidth requirements current VG-6 and VG-8 voice grade lines can be used with appropriate modems for communications between the control and remote radio facilities. The existing voice switches, which provide switching function, display for channel label, generation of signaling for PTT and radio selection and passing various confirmation signals for display to the controller would require modifications to continue to provide similar functions in the VDL Mode 3 environment. In addition, certain VDL Mode 3 system features and functionality may also require modifications to some legacy equipment, e.g., change of display to allow the new channel label to be displayed, adding signaling for preemption of aircraft voice transmission.

For VDL Mode 3 voice operation, vocoders in the GNI will provide voice encoding and decoding to reduce the bandwidth requirement for interfacility communications between the control and remote radio sites. Vocoders in the RIU will be used to convert voice between analog and digital forms for the UHF radios and for local monitoring at the radio site. The VDL Mode 3 system as depicted in Figure B-3 must also support DSB-AM voice operation by incorporating appropriate PCM voice interface between the MDR and the RIU. For the end-state, the following voice modes are supported:

- VDL Mode 3 Voice Operation: Uplink voice from the voice switch (analog voice or PCM voice) is encoded at the GNI to VDL Mode 3 voice. The encoded Mode 3 uplink voice is sent via the RIU to the MDR transmitter for modulation and transmission. For the UHF, the uplink Mode 3 voice from the GNI is decoded at the RIU and converted back to analog voice for modulation and transmission by the UHF radio transmitter. In the downlink, Mode 3 voice from the MDR receiver is sent via the RIU to the GNI. UHF downlink analog voice is converted and encoded to Mode 3 voice at the RIU and sent to the GNI. The VHF and UHF downlink Mode 3 voice will be decoded at the GNI and the resultant voice signals (analog voice or PCM voice) will be sent through the voice switch to the controller.

- DSB-AM Voice Operation: Uplink voice from the voice switch (analog voice or PCM voice) is encoded at the GNI to Mode 3 voice and sent to the RIU. The uplink Mode 3 voice is decoded to MDR-compliant PCM voice in the RIU and the PCM voice is converted to analog voice in the MDR transmitter for AM modulation and uplink transmission. The downlink demodulated analog voice is converted to PCM voice and sent to the RIU, where the PCM voice is encoded to VDL Mode 3 voice for transmission to the GNI. In the RIU the uplink PCM voice will be converted to analog voice and sent to the UHF transmitter for modulation and uplink transmission. The UHF downlink analog voice from the UHF receiver is converted and encoded to Mode 3 voice at the RIU for transmission to the GNI. The VHF and UHF downlink Mode 3 voice is decoded to either analog voice or PCM voice at the GNI, depending upon the voice interface used between the GNI and the voice switch, and sent through the voice switch to the controller.

For data services, the GNI will interface with an A/G Router for connection to the automation system.

Equipment configurations for the MDR and RIU are similar to that of the analog radios and RCE of the current system in that Main/Standby radios are provided for the RCAG and no backup RIU is used at any radio site. The NEXCOM System also has the capability to automatic switching between the main and standby radios operating from the same RIU in the event of a radio failure. This automatic radio switching function is not available in the current DSB-AM system and is provided to enhance the system availability. Manual selection between the main and standby radios by the controllers, available in the current system, will continue to be provided in the NEXCOM VDL Mode 3.

There are no plans at this time to implement VDL Mode 3 at UHF. The next generation UHF radios will continue to use DSB-AM modulation, but will implement MMC capabilities to allow remote monitor and control functions to be performed locally at the radio and remotely from the RIU and the control site MMC Workstation and NIMS.

The NEXCOM System requires site diversity and equipment redundancy to ensure that the overall service availability objectives are met and that there is no single point of failure in the NEXCOM System. The latter is a requirement associated with critical services as defined in NAS-SR-1000.

Appendix E provides detailed Reliability, Maintainability, and Availability analysis of the NEXCOM System to determine the required Mean-Time-Between-Failure (MTBF) for each of the NEXCOM Subsystems.

B.4.2.1 GNI Network Architecture

The A/G Router is the entry point to VDL Mode 3 subnetwork in the ATN. When the data portion of the NEXCOM System is brought into service, it too must have an A/G Router. Because the ATN design requires that IDRP be initialized each time an aircraft contacts an A/G Router (a lengthy process), the number of such routers must be kept to a reasonably small number to reduce the number of IDRP initializations required. The baseline for distributing the A/G Routers in the NAS is based on using one A/G Router in each en route center. The baseline appears to be a good compromise between the extreme cases of a) sharing a single A/G Router for the entire NAS, and b) using one router for each control facility.

Considering that all control facilities need local access to their voice switches and the A/G Routers are available only at the en route centers, a terminal area GNI must, therefore, be routed to a nearby en route center for access to an A/G Router. A GNI data switching function is proposed as part of the overall GNI hierarchy as a means to optimize the subnetwork traffic and reduces disconnect time between GNIs. The GNI data switching function may be implemented as a separate physical entity or integrated with the en route center GNI as shown in Figure B-4. In the latter the GNI with the GNI data switch function must support routing of packets for those GNIs that do not have a GNI data switching function to access A/G Routers for data connectivity. This network hierarchy allows the radio system to transfer aircraft from one ground radio to another ground radio within the router's domain transparent to the router. Only when an aircraft is handed off between facilities supported by different routers will the ATN recognize that the subnetwork connectivity has changed and apply its needed mobile routing overhead (IDRP connection). Since not all control facilities are planned to have their own A/G Router, all facilities needing A/G data services that do not have a co-located router will have their GNIs connecting to the router-equipped facilities for data connection.

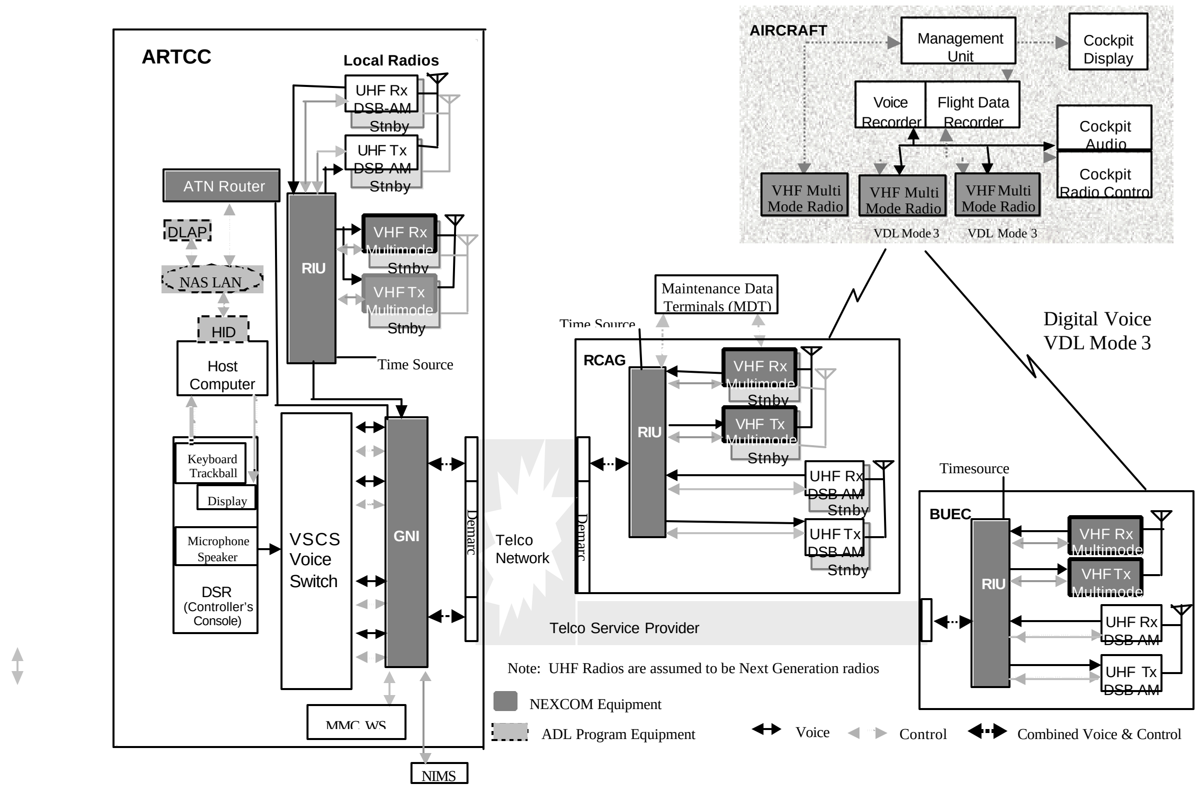


Figure B-3. End-State Architecture (En Route)

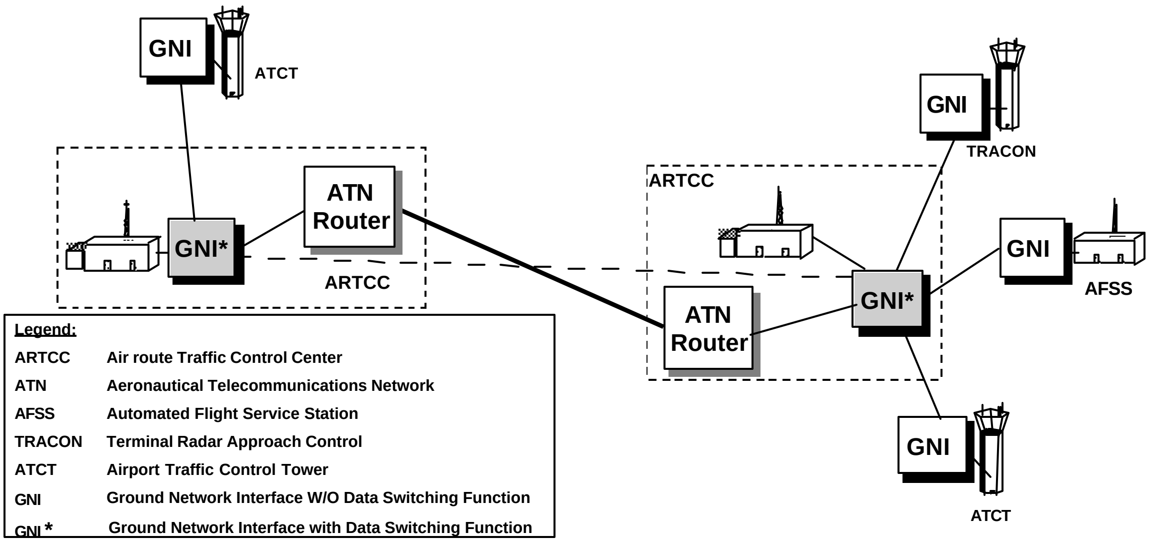


Figure B-4. GNI Hierarchy with GNI Data Switching Function at En Route GNIs

B.4.2.2 Timing System Architecture

In a multiple ground station architecture, multiple ground station radios (e.g., RCAG and BUEC) are used to support separate TDMA nets associated with the same 25 kHz channel in the VDL Mode 3 system. These ground radios would need to be time synchronized to ensure that transmission bursts from radios of different User Groups are not overlapping. One way to ensure that such radios are synchronized is to require that these ground radios are synchronized to a common external time reference. To extend this concept further, if a common time reference is available globally and all NAS ground radios are synchronized to this common time reference, then all the NAS ground radios will be time synchronized and TDMA nets in the NAS will be time synchronized. Even though the system only requires local or regional synchronization, the timing system architecture for NEXCOM is based on the use of a common external time reference for the entire NAS, because such a global time reference is readily available.

One such timing synchronization scheme is based on the RIU subsystem being synchronized to their external time source, which is in turn conditioned by a global time reference. For a small site with one or two RIUs, each RIU can interface directly to its dedicated external time source conditioned by the common time reference. For sites with a large number of RIUs, an external time source that is conditioned by its own external time reference may be used in conjunction with a time distribution system to provide multiple feeds to the collocated RIUs. Such an arrangement is illustrated in Figure B-5. Note that the external time source and the common time reference may need back up depending upon the reliability (MTBF) of the external time source and common time reference available.

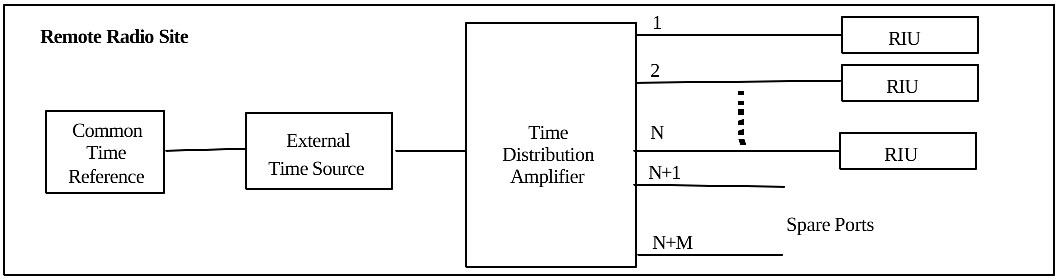


Figure B-5 Timing Distribution System Concept

B.4.2.3 MMC System Architecture

The NEXCOM MMC system is based on a hybrid control concept with central control at the GNI via the NEXCOM MMC Workstation and the NIMS Control Center, and a distributed control providing for local monitor and control at the NEXCOM Subsystem level. Central control provides the NEXCOM System operator full control of the NEXCOM Subsystems in terms of monitoring critical parameters and changing control parameters during normal operation and in supporting remote system certification, as the radio sites are unmanned. Distributed control is provided to allow maintenance personnel local control and monitoring of the radio site equipment during scheduled on-site maintenance and on site diagnostics/troubleshooting. Central MMC functions can be performed from the GNI via the NEXCOM MMC Workstation. Distributed MMC functions are provided locally at the remote radio site RIU and MDR subsystems. Access to the NEXCOM MMC system will be via the standard NIMS MDT with the NEXCOM MDT software. A NEXCOM MMC Workstation is permanently set up to provide the NEXCOM System operator full MMC access at the GNI. The MMC Workstation is loaded with NEXCOM MMC software designed to meet the NEXCOM MMC requirements.

The NEXCOM MMC system architecture used to support this hybrid system concept is shown in Figure B-6 with each MDR connected in series with its RIU and GNI. Figure B-6 also shows the MMC architecture with the MMC signal flow for the NEXCOM end-state system.

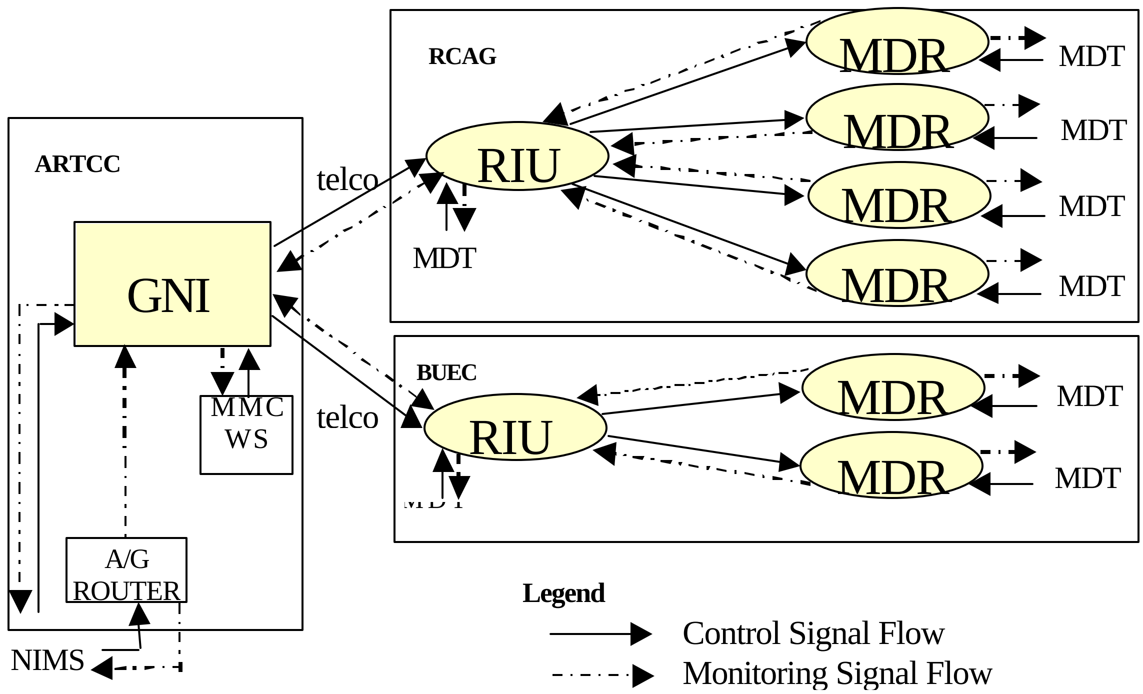
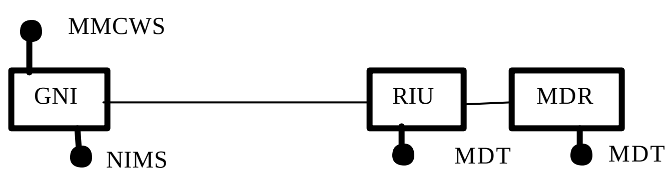


Figure B-6 NEXCOM MMC System Architecture



Access from	Access to		
	GNI	RIU	MDR
MMCWS	L(M,C)	R(M,C)	R(M,C)
NIMS	R(M,C)	R(M,C)	R(M,C)
RIU-MDT	*R(M)	L(M,C)	R(M,C)
MDR-MDT	X	X	L(M,C)

: Port
L : Local
R : Remote
M : Monitor
C : Control
X : Not Permitted

* The RIU's associated channel information

Figure B-6a NEXCOM MMC System Hierarchy

Note: The NEXCOM MMC system as depicted in Figure B-6 illustrates the hierarchy of the NEXCOM MMC system in terms of monitor and control with the GNI at the top, followed by the RIU, and MDR in *that order. The NEXCOM MMC Workstation also has capability to monitor the operation/failure status of the A/G Router. The NEXCOM interfaces with the control site. The A/G Router also interfaces directly with NIMS.*

The NEXCOM MMC system control hierarchy follows the following general rules:

a) Higher level element has control over lower level elements,

b) Lower level elements do not control higher level elements,

c) Elements at the same level do not control each other.

The NEXCOM MMC system monitoring hierarchy follows the following general rules:

a) Higher level element monitors the lower level elements,

b) Lower level elements do not monitor higher level elements,

c) Elements at the same level do not monitor each other

Exceptions to the general rules above include the following:

a) An RIU can monitor through the GNI its associated diversity site RIU/MDRs. However, it cannot control the associated diversity RIU/MDRs.

b) An RIU can monitor, but not control, the GNI associated with that particular channel assignment.

On-site maintenance personnel also have the capacity to control equal or higher level elements of the NEXCOM System through NIMS by using the dial up capability of the MDT for connection to NIMS, provided that the on-site personnel have the proper privilege and authorization.

The GNI acts as the NEXCOM MMC concentrator. The GNI provides a single NEXCOM System interface to NIMS. This interface is capable of passing all available NEXCOM MMC information to NIMS. The GNI will be designed to limit the set of parameters and the type of MMC functions that the NIMS will be able to perform through configuration control from the NEXCOM MMC Workstation. The GNI will be implemented as NIMS proxy agent with NIMS compliant SNMP. No direct NIMS interfaces are provided at the RIU and MDR as such direct interfaces to NIMS at RIU and MDR are deemed unnecessary and not economically justifiable.

B.4.2.4 Information System Security Architecture

ISS Architectures will be developed for proposed solutions that will meet the following security goals:
a) Reduce security risks to the NAS
b) Provide sufficient guarantee that NEXCOM Service can be maintained during an INFOSEC intrusion – accidental or intended

Figure B-4 provides sufficient detail to outline interfaces between NEXCOM Components and NAS Components interfacing to NEXCOM.

The information that follows describes the interfaces between NAS components and NEXCOM components. As network security requirements are dependent on the interface communication protocols used and the peer entities using the interface, the following information is useful in determining these requirements. The information presented consists of an interface diagram and a supporting table. Together, they describe all (known) interfaces to NEXCOM components with an explanation of the interface's purpose and the communication protocols that will probably be used for the interface. The diagram and supporting text may not be complete and are not authoritative. They are provided for illustrative purposes only. The following notes to the diagram apply.

1. Routers, whose only function is to move LAN IP data to/from WAN, are not shown. (The ATN A/G Router does more than this and is shown.
2. Firewalls are not shown, as their exact placement and functionality cannot be known until the security requirements are determined. It is expected that the NEXCOM program will be responsible for the implementation of some firewall functionality to guarantee NAS security. One of the major functions of the security analysis is to determine the exact placement and functionality of the firewalls.
3. The NEXCOM security perimeters are shown on the diagram. The FAA, or another organization (public or private) may operate equipment outside the perimeter. With respect to FAA equipment, the perimeter separates existing NAS components, whose INFOSEC security requirements and procedures already exist, from new NEXCOM equipment, whose INFOSEC requirements must be determined
4. All NEXCOM interfaces that cross the security perimeter have been numbered, as have all communication interfaces between NEXCOM equipment. The peer entities using these interfaces and the protocols used (as known to date) appear in the table.
5. Between any two NEXCOM components only 1 interface is shown. The implementation may be such that multiple physical interfaces are used. If the interface has multiple purposes, the accompanying table lists each.
6. The diagram contains an example of each possible variant in the placement of NEXCOM components. The fact that the TRACON/ATCT site is connected to a 'split' (my term) radio site does not mean that all TRACONs have split radio sites. The placement of A/G ATN Routers has not been determined. What is known at this time is that there will be a limited number of sites with A/G ATN Routers, and the majority of sites will not have A/G ATN Routers. Hence, two sites (and their relationship) are depicted in the diagram to illustrate the two possible interactions with an A/G ATN Router.
7. For the purposes of the table, local means within the same physically protected site, remote means located at a different site from the subject component.
8. The box labeled GNI may contain multiple instantiations of GNIs, as multiple boards on a platform or as a networked complex of platforms. For any such installation there will be only one interface to the HID/NAS LAN and only one interface to the ATN A/G Router. That is, only one GNI will control the interface. This GNI will relay data between interfaces and all other GNIs in the installation.
9. A GNI (or an installation of GNIs, see above) will be connected to more than one RIU. The diagram represents this in only one instance, depicting the GNI that is located within the ARTCC connected to multiple radio sites.
10. The term 'control' is used in two senses in the Table. Radio control refers to the necessary actions, protocols, etc., which allow the controller to switch sites, begin broadcasting, etc. The control in monitor, maintenance and control (MMC) refers to the ability to modify pre-defined system parameters on the subject platform.

Table of Interfaces, Their Purpose, Peers and Protocols

Interface Number	Interface Peers	Information Transferred	Protocol	Comments
1	MMC Work Station – GNI	Maintenance, monitor and control information (MMC)	NIMS (SNMP V3) Vendor Supplied	Workstation assumed to be directly attached to GNI and physically secured.
				NEXCOM components can also be managed remotely via NIMS
2	GNI – RIU	Digitized Voice	TBD	Presumably communications supplied by FTI for radio sites remote from GNI.
		Radio Control (controller directives)	TBD	Same comment as above
		Data	TBD	Same comment as above
		Remote MMC for Radio and RIU	TBD	Same comment as above; GNI relays all NIMS request for RIU and radio status
3	NEXCOM Regional Time Synchronization Source – Local RIU Time Source	Time coordination parameters	TBD	Origin of regional-wide time synchronization yet to be determined.
4	GNI – Air/Ground (A/G) ATN Router	A/G ATN Router initiation control	ISH, Join & leave messages over vendor supplied link protocol	Local A/G ATN Router required to connect VDL Mode 3 to ATN
		Aircraft Router updates	IDRP over vendor supplied link protocol	Use of IDRP causes extended initiation time. Therefore goal is to have each A/G Router cover as large an area as possible. Hence, not all sites have an A/G Router. (*cf*. Interface 5)
		CLNP packets to/from aircraft	CLNP over vendor supplied link protocol	CPDLC and CM are applications which use CLNP

5	GNI – NIMS	Remote MMC	SNMPV3 with encryption over TCP/IP	NIMS defines interface protocol used
	GNI – GNI communications	VDL3 data frames, State information	Vendor supplied over TCP/IP	Supports Make-before-Break
		VDL3 data frames, State information ATN Join/Leave messages	Vendor supplied over TCP/IP	Provides data link connection for sites without ATN A/G Router
	GNI to local broadcast and non-ATN application processor(s)	Application data to/from aircraft under site control	TCP/IP	Application and supporting program yet to be defined
6	GNI- Voice Switch	Controller/Pilot voice (analog &/or digital)	Discrete inputs	In future this may be a T1 line
		Radio control information (e.g., switch among broadcast sites)	Discrete inputs	In future this may be a T1 line
7	NEXCOM A/G ATN Router – local DLAP/CM	CPDLC, CM & ATN Router discovery data	ES-IS & CLNP over FAA defined LAN protocol	Protocol (LAN and WAN) between CLNP machines determined by CPDLC program
	NEXCOM A/G ATN Router – ATN Backbone	ATN routing protocols (IS-IS, IDRP)	CLNP over FAA defined LAN protocol	Protocol (LAN and WAN) between CLNP machines determined by CPDLC program
		Aircraft application traffic to/from other sites	CLNP over FAA defined LAN protocol	Protocol (LAN and WAN) between CLNP machines determined by CPDLC program
	NEXCOM A/G ATN Router – NIMS server	Remote MMC	SNMPV3 with encryption over TCP/IP	NIMS defines interface protocol used
8	RIU – Local VHF Radio or local VHF transmitter	Controller/pilot voice; Radio control information; MMC; CPDLC & CM data	Fractional T1 RIU protocol	Security requirements may differ between local and remote cases

9	RIU – Local UHF Radio or local UHF transmitter	Voice	Analog voice	Security requirements may differ between local and remote cases
		Radio control MMC	Digital	Same comment as above
10	RIU – Time Source	Time reference protocol	Discrete l pps and Time Of Day inputs	
11	MDT – VHF MDR	Local MMC	Vendor supplied (RS-232 based)	Security requirements already specified in MDR Specification
12	VHF Radio – Airborne VHF radio	VDL3 Network management	As specified in RTCA DO 224A	Ground may set or read control information (XID exchange)
		Controller/pilot voice	As specified in RTCA DO 224A	
		CPDLC, CM data	ATN	Application traffic transparent to VDL3
13	UHF Radio – Airborne UHF radio	Controller/pilot voice	Analogue	
14	RIU - Remote VHF Receiver	Controller/pilot voice; Radio control information; MMC; CPDLC & CM data	Same as interface 8	FTI supplied communications at some sites
15	RIU – Remote UHF Receiver	Voice; MMC; Radio control	Same as interface 9	FTI supplied communications at some sites
16	RIU - MDT	MMC	Vendor supplied	Probably same requirements as interface 11
17	MDT – UHF MDR	MMC	Vendor Supplied (RS232 based)	Security requirements specified in VHF MDR may suffice

Table B-1 Interfaces, Their Purpose, Peers and Protocols

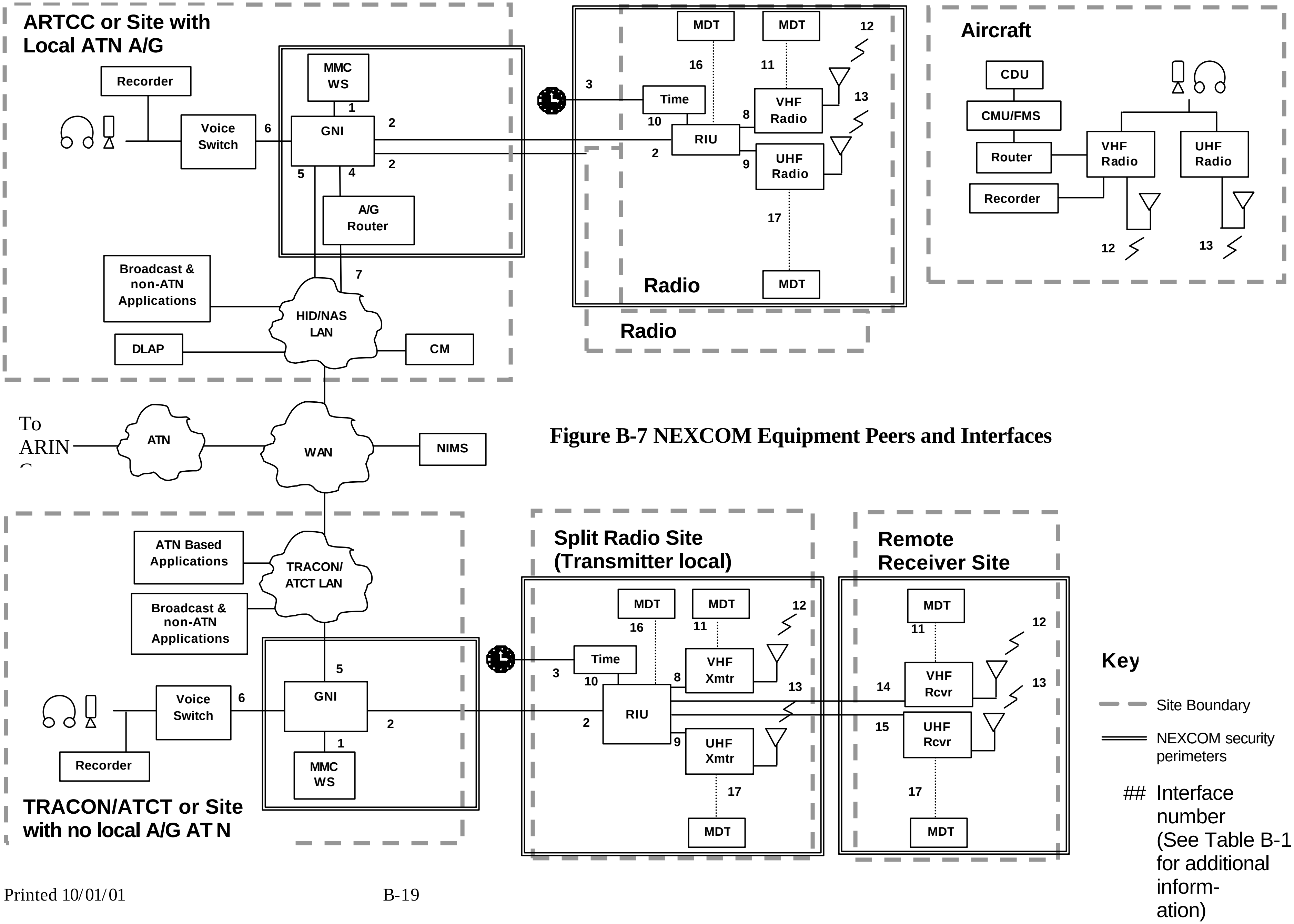


Figure B-7 NEXCOM Equipment Peers and Interfaces

B.4.2.5 Separated Transmitter/Receiver System Architecture

For most of the site configurations in NEXCOM the baseline end-state system architecture depicted in Figure B-3 for the En Route domain applies with the possible exception of the Separated Transmitter/Receiver (STR) configuration, which is common in the terminal environment. Based on the baseline system architecture of Figure B-3, the offsite receivers (both MDR and UHF) would require to be connected, via telecommunications links, to the RIU at the transmit site for proper VDL Mode 3 operation. This would require a high-speed (fractional T1 rate) digital link to be used between the MDR receivers at the receive site and the RIU at the transmit site. Furthermore, additional telecommunications link(s) would be required to connect the UHF receiver analog voice signal, MMC data (especially for future UHF radios with enhanced MMC capabilities), and radio signaling information to and from the RIU at the transmit site. These connectivity requirements between the receive site and the RIU at the transmit site pose severe telecommunications link requirements to the NEXCOM System, from both a bandwidth requirement and the number of circuits that may be required. Cost aside, one of the major concerns is that wideband digital telecommunications links may not be readily available for all the STR sites. One alternative in resolving this issue is to use a second RIU to interface locally with the MDR and UHF receivers and use the standard RIU/telecommunications link interface to connect to the GNI as a means to reduce the overall telecommunications requirements for the STR system. Note that in this architecture the receiver and its transmitter are operating off different RIUs, which is no different from using the RCAG for transmission and BUEC for receiving in Figure B-3 of the baseline system architecture. This architecture is illustrated in Figure B-8. In this architecture each receiver and each transmitter are operating off different RIUs. In reality, the transmitter/receiver may also be separately located with up to 4 local sites. For simplicity, only the portion that is different from the baseline architecture of Figure B-3 is shown n Figure B-8. The telecommunications link is requirement between the RIU and GNI can be normally handle with a 56 kbps digital link or by a number of VG-6 lines for sites with no digital telecommunications connectivity. The GNI will be implemented such that any transmitter can be paired with any receiver.

B.4.2.6 Telecommunications Link Configurations

Telecommunications links are required to provide communications between GNI in a control site to RIUs in remote radio sites. This link may consist of a single digital circuit with sufficient bandwidth or multiple voice grade circuits. For example, multiple VG-6 lines or a single 56 kbps digital circuit may be used to support the full communications capability between a RIU and its GNI. For split transmitter and receiver sites, the RIU is collocated with the transmitter and, as an option, a second RIU will be installed at the receive site to interface with the MDR and UHF radios. Separate telecommunications links are required to connect the transmit site RIU and the receiver site RIU to their associated GNI(s) at the control site. This configuration is depicted in Figure B-8 of Appendix B. For communications between RIU and GNI it is envisioned that backup telecommunications links may be desirable for certain installations to improve the overall service availability. In the NEXCOM System three levels of redundancy are assumed for the telecommunications link between the GNI and a RIU:

1. No backup
2. Standby telecommunications backup
3. Hot telecommunications backup

In the case of No Backup, the telecommunications link is single-threaded. Failure of the telecommunications link will cause interruption in the GNI-RIU communications and would require the Telecommunications Link service provider to restore the link. The NEXCOM System must restore its service by using a separate GNI RIU connection until the failed link is restored. In the case of Standby Telecommunications Backup, two telecommunications links will be connected between a RIU and its GNI, one designated as primary and the other as backup. Only the primary link will be connected to pass data between the RIU and GNI. When the primary telecommunications link fails the GNI and RIU can be commanded to restore operation using the backup link. Typically, the primary and backup telecommunications links are based on dissimilar communications links with different performance characteristics, e.g., delay and availability. Since a backup link is typically less reliable than its primary, switch back to the primary link is normally performed upon restoration of the primary link. The switching from the primary to the backup link is selectable to be automatic or manual. In the automatic mode, when the primary link fails the GNI and RIU independently detect the link failure and switch to the backup link automatically and independently. In the manual mode, detection of the link failure will be performed as in the case of the automatic mode but will not cause switching of the telecommunications link automatically. The detection of link failure will cause system alarms to be generated and forwarded to the MMC system. The MMC system will be used to switch manually from the failed link to its backup link with appropriate MMC commands. The switchback from the backup link to the primary link is also selectable to be either automatic or manual. In the case of automatic switchback, the GNI will coordinate with the RIU over the backup link for the switching to ensure that no loss of data will result from the switching. Switchback in the manual mode will be performed by manual entry of commands through the MMC system. In the case of Hot Backup, two telecommunications links will be connected between a RIU and GNI. Both telecommunications link in a hot backup configuration pass data between the RIU and GNI to ensure that failure to either one link will not interrupt communications between the GNI and RIU. This might require that data received on both lines be fully processed by the GNI and RIU. A failure to either one of the two links must not result in any performance degradation. There should not be any loss of data due to the failure of one of the two links. Communications between the GNI and RIU will be interrupted only when both links fail. The two telecommunications links in a hot backup configuration can be dissimilar in their characteristics, e.g., delay and availability, but the performance of each link must meet minimum performance requirements appropriate to the service it carries. If there are different delays between the two links, equalization within NEXCOM components may be required. The difference in delay characteristics should not cause any loss of data between the RIU and GNI when either link fails.

Note: In figure B-8 each receiver and each transmitter is operating off of different RIUs.

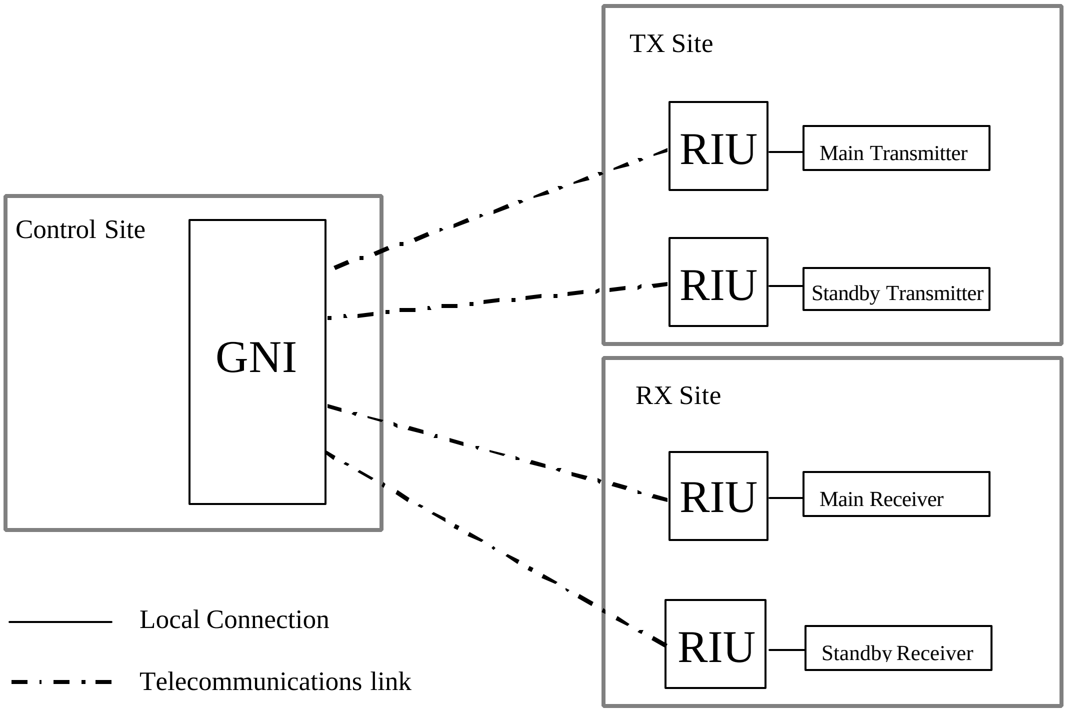


Figure B-8 End-State Architecture for STR Sites

B.5 NEXCOM Concept of Use

Currently being defined by RTCA SC-198.

APPENDIX C NEXCOM SECURITY REQUIREMENTS

C.1 NEXCOM System Requirements Document (SRD) Security Requirements

The security requirements presented in this document were developed based on the following:

- The NEXCOM Requirements Document
- Security Objectives defined in the NIST Common Criteria Model adopted by ISO 15408
- Information System Security (ISS) Policies derived from the NAS ISS Architecture

This appendix is structured as follows:

- Section two describes the security objectives.
- Section three defines assumptions.

C.2 Security Objectives

This section includes the technical security objectives and requirement policies of the NEXCOM System and it's supporting environment. These objectives reflect the intent to counter identified threats and vulnerabilities and to comply with FAA security policies.

C.2.1 Technical Security Objectives

The following objectives are based on language from the Common Criteria (CC). Changes have been made to the language to accommodate readers unfamiliar with the CC. The objectives below are specific to the derived security requirements in the rest of this document and are given as background information.

Objective Name	Security Objective
DOMAIN SEPARATION	The NEXCOM System security functions create and maintain separate domain or domains of execution in which it can execute without interference from all subjects (persons and systems) outside of this domain.
KNOWN	The NEXCOM System ensures that, except for a well-defined set of allowed actions, all administrative and maintenance users are identified and authenticated before being granted access to the system or its resources. Aircraft shall have individual identification codes.
ACCESS	The NEXCOM System allows access by authenticated users to those resources for which they have been authorized, and deny access to those resources for which they are not authorized. Access for ATC and Pilots may be role based.
MISUSE	The NEXCOM System security functions mitigate the threat of malicious actions by authenticated users (e.g. by holding all authenticated users accountable).
AUTHORIZE	The NEXCOM System provides the ability to specify and manage “resource access permission” to be assigned to its users.
BYPASS	The NEXCOM System prevents all software and users from bypassing or circumventing system security policy enforcement.
ACCOUNT	The NEXCOM system ensures that all system users can be held accountable for their security-relevant actions.
INFO-FLOW	The NEXCOM system ensures that any information flow control policies are enforced between system components and at the system external interfaces.
OBSERVE	The NEXCOM system ensures that its security status is not misrepresented to the administrator or user.
DETECT	The NEXCOM system has the capability to detect system failures and breaches of security.
RECOVER	The NEXCOM system provides for recovery to a secure state following a system failure, discontinuity of service, or detection of a security flaw or breach.
AVAILABLE	The NEXCOM system protects itself from denial-of-service attacks, including those due to a shared resource exhaustion.
NETWORK	The NEXCOM system has the capability to meet its security objectives in a networked environment.

Table C-5-2 Security Objectives

C.3 Assumptions

This subsection describes connectivity and non-system assumptions that impact the security of the NEXCOM system.

It is the NEXCOM System’s responsibility to address security vulnerabilities introduced not only from NEXCOM System components but also through remote access, telecommunication’s network design, interfaces, and peripheral devices connected to the NEXCOM System. NEXCOM System components are connected to a network containing other devices that use various protocols, operate in a shared user environment, and use technologies that may introduce new vulnerabilities to the actual NEXCOM Subsystem. In addition, interconnection to systems such as the ATN Router and CPDLC may introduce new vulnerabilities.

Appendix B.4.2.4, Information System Security Architecture provides an overview of a projected NEXCOM architecture and it's interconnected subsystems.

The overriding security principle for the NEXCOM Subsystems is that everything is assumed to be insecure unless known otherwise.

APPENDIX D Requirements Traceability Matrix

The traceability matrix in Table D-1 shows the source document or organization for the requirements contained in this SRD.

Table D-1. Requirements Traceability Matrix ¾ SRD Requirement Sources

SRD Section	SRD Title	Requirements	Source Document
3.2.1.1.1	Site Configurations	a) The NEXCOM System shall support the following site configurations: 1. Single RCF 2. Separated transmitter/receiver sites 3. Primary RCF with backup site (e.g., BUEC) 4. Diversity site group 5. Dual control	RD Section: 4; 10.2
3.2.1.1.2	NAS ATC Facility Compatibility	a) The NEXCOM System shall operate within existing NAS ATS Facilities.	RD Section: 3.2.15.1; 4.5.1; 8.8.2.1; 10.2.1.2
3.2.1.2.1	Coexistence with the Present System	a) All NEXCOM modes specified in Section 3.2.2a. shall coexist with the current VHF/UHF DSB-AM system throughout the NAS.	SRD Section: 3.2.2a; 10.4.1
3.2.1.2.2	Coexistence Among NEXCOM Modes	a) All NEXCOM modes specified in Section 3.2.2.a. shall coexist with all NEXCOM modes throughout the NAS.	RD Section: 10.3.1; 10.4.1; SRD Section: 3.2.2a
3.2.1.2.3	Coexistence with other Existing Systems	a) The NEXCOM System shall coexist with any existing FAA systems.	RD Section: 10.4.1
3.2.2	Modes of Operation	a) The NEXCOM System shall operate in each of the following selectable modes: 1. VDL Mode 3 2. 25 kHz DSB-AM [RD 2.1; RD 5.3.2; RD 10.2.1] 3. 8.33 kHz DSB-AM	RD Section: 3.2.12.1; 2.1; 5.3.2; 10.3.1
3.2.2	Modes of Operation	b) The NEXCOM System shall operate a UHF DSB-AM mode simultaneously with VHF modes in each User Group as needed.	RD Section: 3.1.8.1

SRD Section	SRD Title	Requirements	Source Document
3.2.2	Modes of Operation	c) The NEXCOM System shall meet United States regulatory functional requirements specified in [FCC (Part 2 and 87), NTIA (Chapters II, V, VII, X, and ANNEX B)].	FCC (Part 2 and 87), NTIA (Chapters II, V, VII, X, and ANNEX B)
3.2.2.1	VDL Mode 3 Standardization	a) The NEXCOM System shall meet the VDL Mode 3 functional requirements for ground systems specified in RTCA DO-224A.	RD Section: 3.2.12.1; 3.2.13.2 RTCA/DO-224A
3.2.2.2	25 kHz DSB-AM Standardization	a) The NEXCOM System shall meet the 25 kHz DSB-AM functional requirements specified in FAA-P-2883 and FAA-P-2884.	RD Section: 3.2.13.2
3.2.2.3	8.33 kHz DSB-AM Standardization	a) The NEXCOM System shall meet the 8.33 kHz DSB-AM functional requirements specified in ICAO Annex 10 and ETSI specification EN-300-676.	RD Section: 3.2.13.2; 5.4.1
3.2.2.4	Channel Labeling	a) The NEXCOM System shall operate with the ICAO channel labeling for each of the modes identified in section 3.2.1.a.	RD Section: 3.2.13.2
3.2.3.1	Voice Communications Requirements	a) The NEXCOM System shall allow all users in a Talk Group to monitor all voice communications within that Talk Group. [RD 3.1.1.2]	RD Section: 3.1.1.2; 3.1.1.3; 3.1.5.1; 3.2.3.1
3.2.3.1	Voice Communications Requirements	b) Overloading of data communication shall not prevent the operation of the voice communication.	RD Section: 7.2.1; 7.3.1.1
3.2.3.1	Voice Communications Requirements	c) The NEXCOM System shall meet the 8.33 kHz DSB-AM functional requirements specified in ICAO Annex 10 and ETSI specification EN-300-676.	ICAO Annex 10 and ETSI specification EN-300-676
3.2.3.1.1	Voice Channels	a) The NEXCOM System shall interface with existing VSCE (e.g., VSCS, ETVS, ICSS, RDVS, STVS) via existing interfaces (e.g., Single channel (V+U) and quad channel (V/U/M/S)). [FAA-E-2885]	FAA-E-2885
3.2.3.1.2	Voice Encoding/Decoding	a) The NEXCOM System/VSCE interface shall include: 1. Analog voice 2. Digital voice	RD Section 10.2; 3.1.1.4 Note; 3.1.5.1 Note
3.2.3.1.2	Voice Encoding/Decoding	b) Voice encoding/decoding for VDL Mode 3 shall be in accordance with the vocoder algorithm specified in ICAO Annex 10, Vol. III, Part 1, Chapter 6.	SRD Section 3.2.2

SRD Section	SRD Title	Requirements	Source Document
3.2.3.1.3.1	Uplink Path	a) The NEXCOM System shall transmit uplink voice out of the radio at the site(s) selected by the controller.	SRD Section 3.2.2
3.2.3.1.3.2	Downlink Path	a) The NEXCOM System shall route all downlink voice output from all selected receivers to the VSCE.	SRD Section 3.2.2
3.2.3.1.3.2.1	Local Audio Monitoring	a) The NEXCOM System shall present the downlink voice, in an analog format, received at the radio site for local monitoring at the remote site.	FAA-P-2884
3.2.3.1.3.2.1	Local Audio Monitoring	b) The NEXCOM System shall present the uplink voice, in an analog format, received and the remote site for local monitoring at the remote site.	FAA-P-2884
3.2.3.1.3.2.1	Local Audio Monitoring	c) The NEXCOM System shall present the downlink voice, in an analog format, received at the control site for local monitoring at the control site.	FAA-E-2885
3.2.3.1.3.2.1	Local Audio Monitoring	d) The NEXCOM System shall present the uplink voice, in an analog format, received at the control site for local monitoring at the control site.	FAA-E-2885
3.2.3.2.1	Data Service	a) The NEXCOM System shall provide for a subnetwork for two-way addressed data communications between ground and aircraft systems. [RD Att 2]	RD Section: 3.1.9.1; Attachment 2 par.2 Data Communications
3.2.3.2.1	Data Service	b) The NEXCOM System shall provide for uplink broadcast using the same subnetwork as the two-way addressed service. [RD Att 2]	RD Section: 3.1.9.1; Attachment 2 par.2 Data Communications
3.2.3.2.1.1	ATN Compatibility	a) The NEXCOM System shall inter-operate with ATN-based ground and aircraft applications as defined in the ICAO Annex 10, and ICAO Doc 9705 (Edition 3). [RD Att 2]	RD Section: 3.2.17.1; Attachment 2 par. 7 ATN Compatibility; ICAO Annex 10; ICAO Doc 9705 (Edition 3)
3.2.3.2.1.2	Make-before-Break Support	a) The NEXCOM System shall support Make-before-Break (MbB) capabilities as described in RTCA DO-224A, Section 3.3.3.3.	SRD Section: 3.2.2.1
3.2.3.2.1.3	User Authentication	a) The NEXCOM System shall support authentication of user attempts to initialize connections. [RD 7.3.1.1]	RD Section: 7.2.1; 7.3.1.1
3.2.3.2.1.3	User Authentication	b) The NEXCOM System shall not permit any of its functions or components to be used to access unauthorized parts of the NAS external to the NEXCOM System. [RD Att 2]	RD Section: 7.2.1; 7.3.1.1

SRD Section	SRD Title	Requirements	Source Document
3.2.3.3	Continuous Broadcast	a) The NEXCOM System shall provide continuous ground-to-air broadcast within a service volume for the modes identified in section 3.2.2.	RD Section: 3.1.3.1
3.2.3.4.1	Entry Into a Talk Group	a) The NEXCOM System shall allow any aircraft operating in the correct mode entry into any Talk Group within the Talk Group's service volume. [RD 3.1.1.3]	RD Section: 3.1.1.2; 3.1.2.1
3.2.3.4.2	Automated Transfer of Communication	a) The NEXCOM System shall upload channel assignment information to an aircraft system via the VDL Mode 3 Next Net capability defined in RTCA DO-224A. [RD Att 2]	RD Section: Attachment 2 par. 12 Automatic Transfer of Communication
3.2.3.4.3	Subnetwork Connectivity Reporting	a) The NEXCOM System shall report to the A/G Router connectivity changes to the subnetwork that affect routing decisions. [ICAO Doc 9705]	ICAO Doc 9705
3.2.3.5	Ground Station Operations	a) The NEXCOM System shall support diversity site group operation (See Appendix A).	RD Section: 3.2.10.1; 3.2.15.1; 3.10.2.1; 3.10.4.1
3.2.3.5	Ground Station Operations	b) The NEXCOM System shall schedule the M burst in which it will transmit its VDL Mode 3 timing Beacon to coordinate ground transmitters. [SRD 3.2.1]	SRD Section: 3.2.2.1
3.2.3.5	Ground Station Operations	c) In any User Group, the active transmitter Beacon shall not cause harmful interference with any other NEXCOM Subsystems operating on the same frequency. [SRD 3.2.1]	RD Section: 10.3.1; 10.4.1; SRD Section: 3.2.2.1
3.2.3.6.1	PTT Control	a) The NEXCOM System voice channel uplink access shall be based on PTT assertion. [RD 3.1.4]	RD Section: 3.1.4.1
3.2.3.6.1	PTT Control	b) The NEXCOM System shall provide confirmation of PTT/PTT Release on a Talk Group basis. [RD 3.1.7.1]	RD Section: 3.1.1.4; 3.1.7.1
3.2.3.6.1	PTT Control	c) The NEXCOM System shall be configurable to provide confirmation of PTT/PTT Release based on the reception of the transmitted signal. [RD 3.1.7.1]	RD Section: 3.1.1.4; 3.1.7.1

SRD Section	SRD Title	Requirements	Source Document
3.2.3.6.2	Preemption of Aircraft Voice Transmissions	a) The NEXCOM System shall provide a selectable function that allows the controller to preempt aircraft voice transmissions on a per Talk Group basis as follows. [RD 3.3.1; RD 3.3.2; DO 224A, 9/13/01, 3.3.2.1.1.1] 1. Preemption Off (function disabled) 2. Preemption On (Upon PTT activation preemption occurs) 3. Momentary Preemption on a single PTT basis (Dynamic function selectable by the controller)	RD Section: 3.3.1; 3.3.2 RTCA/DO 224A Section: 3.3.2.1.1.1
3.2.3.6.2	Preemption of Aircraft Voice Transmissions	b) The NEXCOM System shall provide confirmation to the VSCE of the assertion of preemption of aircraft voice transmission by the ground station for the duration of the preemption.	RD Section: 3.1.1.4
3.2.3.6.3	Squelch Break	a) The NEXCOM System shall squelch background noise in the absence of a signal that is above a preset threshold.	FAA-P-2884
3.2.3.6.3	Squelch Break	b) The NEXCOM System shall provide squelch break indication on the selected receivers for the duration of the squelch break to the control facility. [RD 3.1.7.1]	RD Section: 3.1.7.1
3.2.3.6.4	Received Audio Muting	a) The NEXCOM System shall support mute/unmute of the received audio at the control site based on a per Talk Group basis.	FAA-E-2885
3.2.3.6.4	Received Audio Muting	b) The NEXCOM System shall support mute/unmute of the received audio at the radio site on a per Talk Group basis based on the VSCE input.	FAA-P-2884; FAA-E-2885
3.2.3.6.4	Received Audio Muting	c) The NEXCOM System shall provide confirmation of the received audio muting/unmuting from the radio site to the VSCE.	RD Section: 3.1.1.4
3.2.3.6.4.1	PTT Mute/Attenuation	a) The NEXCOM System shall be configurable (on a per Talk Group basis) to mute (at the control site) any received uplink audio (provided to the VSCE) interface.	FAA-E-2885
3.2.3.6.4.1	PTT Mute/Attenuation	b) The NEXCOM System shall be configurable (on a per Talk Group basis) to mute (at the control site) downlink audio (provided to the VSCE interface) during the assertion of PTT.	FAA-E-2885
3.2.3.6.4.1	PTT Mute/Attenuation	c) The NEXCOM System shall be configurable (on a per Talk Group basis) to attenuate (at the remote site) downlink audio during the assertion of PTT.	FAA-E-2885
3.2.3.6.4.1	PTT Mute/Attenuation	d) The NEXCOM System shall be configurable (on a per Talk Group basis) to continue to attenuate (at the remote site) downlink audio after the release of PTT (for up to 600 ms, 0 to 600 ms in 10 ms increments).	FAA-E-2885

SRD Section	SRD Title	Requirements	Source Document
3.2.3.6.4.2	Commanded Mute	a) The NEXCOM System shall support mute/unmute of the received audio (at the radio site) (on a per Talk Group basis) based on the operator input. (e.g., VSCE, MMC, etc.)	FAA-E-2885
3.2.3.6.4.2	Commanded Mute	b) The NEXCOM System shall provide confirmation of the received audio muting/unmuting (at the radio site) to the operator. (e.g., VSCE, MMC, etc.)	FAA-E-2885
3.2.3.6.5.1	Radio Selection	a) The NEXCOM System shall select radio resources (i.e., Main, Standby, and BUEC transmitters and receivers) for voice operation based on operator input (e.g. VSCE, MMCWS, and/or MDT).	RD Section: 3.1.1.1
3.2.3.6.5.1	Radio Selection	b) The NEXCOM System shall provide confirmation on radio resource selection to the Operator (e.g. VSCE, MMCWS, and/or MDT) upon completion of radio switching.	RD Section: 3.1.1.4
3.2.3.6.5.1	Radio Selection	c) The NEXCOM System shall support independent selection of radio resources for voice operation by different Talk Groups.	RD Section: 3.1.1.1
3.2.3.6.5.1	Radio Selection	d) The NEXCOM System shall cause no loss of management and user information due to selection of radio resources for voice operation.	SRD Section: 3.2.3.6.5.1
3.2.3.6.5.1	Radio Selection	e) When any PTT is activated, the NEXCOM System shall inhibit the radio resource select functions for that Talk Group (i.e., inhibit the re-routing of the voice and control signals and inhibit the switching of the antenna transfer relay).	FAA-E-2885 Section: 3.2.2.3.1
3.2.3.6.5.2	Automatic Radio Switching	a) When the Main and Standby radios are serviced by the same RIU, and so configured, the NEXCOM System shall automatically perform M/S radio switching from the selected to the alternate radio, without operator intervention, in the event of a failure of the selected radio.	RD Section: 3.1.9.1; Attachment 2 par. 8 Automatic Failure Detection and Fault Isolation
3.2.3.6.5.2	Automatic Radio Switching	b) The automatic M/S radio switching function shall be disabled by subsequent operator manual M/S radio selection.	SRD Section: 3.2.6.5.2
3.2.3.6.5.2	Automatic Radio Switching	c) If the automatic M/S radio switching function is disabled by subsequent operator manual M/S radios selection, the automatic M/S radio switching function shall remain disabled until manually reset.	SRD Section: 3.2.6.5.2
3.2.3.6.5.2	Automatic Radio Switching	d) Automatic radio switching shall only be performed when the alternate radio is operational.	SRD Section: 3.2.6.5.2

SRD Section	SRD Title	Requirements	Source Document
3.2.3.6.6	Channel Busy Signal	a)The NEXCOM System shall provide a signal to the VSCE that the channel requested by the controller is occupied.	RD Section: 3.1.7.1; Attachment 2 par. 8 Automatic Failure Detection and Fault Isolation
3.2.3.6.7	Dual Control	a) The NEXCOM System shall provide a dual control priority mode to share control of a Talk Group by two different control facilities.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-2885 Section: 3.2.2.3.1.3
3.2.3.6.7	Dual Control	b) The NEXCOM System shall provide a dual control non-priority mode to share control of a Talk Group by two different control facilities. [FAA-E-2885, 3.2.2.3.1.3]	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-2885 Section: 3.2.2.3.1.3
3.2.3.6.7.1	Priority Mode	a) Each control facility shall be defined as either a primary or secondary for a specific paired Talk Group. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.1	Priority Mode	b) The primary control facility shall lockout the secondary control facility during transmission. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.1	Priority Mode	c) During the transmission by the primary facility, a lockout signal shall be provided back to the secondary control facility. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.1	Priority Mode	d) The NEXCOM System shall provide a PTT confirmation signal back to both control facilities. [FAA-E-2885, 3.2.2.3.1.3.2]	RD Section: 3.1.1.4; SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2

SRD Section	SRD Title	Requirements	Source Document
3.2.3.6.7.1	Priority Mode	e) The primary control facility PTT shall override the secondary control facility voice communication on the shared Talk Groups. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.1	Priority Mode	f) The communication on the receive path shall always be open to both facilities. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.1	Priority Mode	g) When the mute function is selected, the facility shall mute its own receive path independent of the mute selection of the other facility. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.1	Priority Mode	h) The selection of the mute for one Talk Group shall be independent of the other Talk Group.	RD Section: 3.1.1.4; SRD Section: 3.2.6.7;
3.2.3.6.7.1	Priority Mode	i) The site not asserting PTT shall hear the other site's transmit audio.	SRD Section: 3.2.6.7
3.2.3.6.7.1	Priority Mode	j) Upon termination of transmission by the primary facility, the lockout condition to the secondary facility shall be removed automatically. [FAA-E-2885, 3.2.2.3.1.3.2]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.2
3.2.3.6.7.2	Non-Priority Mode	a) The NEXCOM System shall provide a transmission path for the control facility that initiated the transmission first. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.2	Non-Priority Mode	b) The NEXCOM System shall provide a confirmation signal back to the control facility that initiated the transmission first. [FAA-E-2885, 3.2.2.3.1.3.1]	RD Section: 3.1.1.4; SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1

SRD Section	SRD Title	Requirements	Source Document
3.2.3.6.7.2	Non-Priority Mode	c) During the transmission by one facility, the second facility shall be locked out. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.2	Non-Priority Mode	d) During the transmission by one facility, a lockout signal shall be provided back to the secondary control facility. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.2	Non-Priority Mode	e) The communication on the receive path shall always be available to both facilities. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.2	Non-Priority Mode	f) When the mute function is selected, the facility shall mute its own receive path independent of the mute selection of the other facility. [RD 10.2.1.1; FAA-E-2885, 3.2.2.3.1.3.1]	RD Section: 10.2.1.1; SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.6.7.2	Non-Priority Mode	g) Upon the termination of transmission by the facility that initiated the transmission, the lockout condition to the other facility shall be removed. [FAA-E-2885, 3.2.2.3.1.3.1]	SRD Section: 3.2.6.7; FAA-E-2885 Section: 3.2.2.3.1.3.1
3.2.3.7	Ground Stuck Microphone Correction	a) The NEXCOM System shall provide a function which can be enabled, that disables transmission by a specific ground MDR.	RD Section: 2.1; 3.2.1.2; 3.2.4.1; 3.2.4.2; FAA-P-2884
3.2.3.7	Ground Stuck Microphone Correction	b) This transmission disabling function shall have a configurable time component so that when the duration of that MDR's keying input exceeds the configured time, transmission stops. [RTCA DO 224A, 3.3.2.1.1.1; RD 3.3.1; RD 3.3.2]	RD Section: 3.2.2.1; 3.3.1; 3.3.2; RTCA DO 224A, 3.3.2.1.1.1

SRD Section	SRD Title	Requirements	Source Document
3.2.3.7	Ground Stuck Microphone Correction	c) The NEXCOM System shall allow the controller to reinitiate the transmission after this function has disabled transmission by releasing the PTT command and reapplying it. [RD 3.3.1; RD 3.3.2; RTCA DO 224A, 3.3.2.1.1.1]	RD Section: 3.2.2.1; 3.3.1; 3.3.2; RTCA DO 224A, 3.3.2.1.1.1
3.2.3.8.1	NEXCOM/Telecommunications Interfaces	a) The NEXCOM System telecommunications shall provide full-duplex operation.	RD Section: 4.10.2
3.2.3.8.1	NEXCOM/Telecommunications Interfaces	b) The NEXCOM System shall operate with existing 4-wire analog telecommunications and selected digital telecommunications between control and remote radio facilities.	RD Section: 4.10.2
3.2.3.8.1	NEXCOM/Telecommunications Interfaces	c) Analog telecommunications shall meet the interface requirements as specified in Bellcore TR-NWT-000335 Voice Grade Special Access Service Transmission Parameter Limits and Interface Combinations, May 1993.	RD Section: 4.10.2
3.2.3.8.1	NEXCOM/Telecommunications Interfaces	d) Digital telecommunications shall meet the interface requirements specified in Bellcore GR-499-CORE Transport Systems Generic Requirements (TSGR) Common Requirements, December 1998.	RD Section: 4.10.2
3.2.3.8.1	NEXCOM/Telecommunications Interfaces	e) The NEXCOM System shall support three telecommunication link redundancy configurations: 1. No backup 2. Standby backup 3. Hot telecommunications backup	RD Section: 4.10.2
3.2.3.8.2	Telecommunications Restoration Functional Requirements	a)The NEXCOM shall have a selectable function to restore service over the original telecommunications link, for telecommunications service interruption of less than 3 seconds in duration.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-2885
3.2.3.8.2	Telecommunications Restoration Functional Requirements	b)When a backup telecommunications link is available, the NEXCOM System shall have a selectable function to restore service over the backup telecommunications link automatically upon detection of the primary telecommunications link failure for telecommunications link service interruption that is 3 seconds or longer in duration.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-2885
3.2.3.8.2	Telecommunications Restoration Functional Requirements	c)Upon confirmation of restoration of the primary telecommunications link, the NEXCOM System shall switch its operation back from the backup telecommunications link to the primary telecommunications link automatically.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-

SRD Section	SRD Title	Requirements	Source Document
			2885
3.2.3.8.2	Telecommunications Restoration Functional Requirements	d)When both links are functioning properly, the automatic switch back to the primary telecommunications link shall be disabled until the PTT is de-asserted.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1; FAA-E-2885
3.2.3.8.2.1	Standby Telecommunications Restoration Functional Requirements	a) The NEXCOM System shall restore service over the original telecommunications link, for telecommunications service interruption of less than 1 second in duration.	FAA-E-2885
3.2.3.8.2.1	Standby Telecommunications Restoration Functional Requirements	b) When a backup telecommunications link is available, the NEXCOM System shall have a selectable function to restore service over the backup telecommunications link automatically upon detection of the primary telecommunications link failure for telecommunications link service interruption that is 1 second or longer in duration.	FAA-E-2885
3.2.3.8.2.1	Standby Telecommunications Restoration Functional Requirements	c) Upon confirmation of restoration of the primary telecommunications link and so configured, the NEXCOM System shall switch its operation back from the backup telecommunications link to the primary telecommu nications link automatically.	FAA-E-2885
3.2.3.8.2.1	Standby Telecommunications Restoration Functional Requirements	d) When both links are functioning properly, the automatic switch back to the primary telecommunications link shall be disabled until the PTT is de-asserted.	FAA-E-2885
3.2.3.8.2.2	Hot Telecommunications Backup Functional Requirements	a) Failure or any performance degradation to either one of the telecommunications interfaces in the hot backup configuration shall not degrade the NEXCOM System operation.	FAA-E-2885

SRD Section	SRD Title	Requirements	Source Document
3.2.4	Maintenance, Monitoring and Control (MMC) Functional Requirements	a) The NEXCOM System shall follow the following MMC hierarchy rules for control and monitoring: 1. Higher level subsystems have control and monitoring over lower level subsystems, i.e., GNI controls and monitors its RIU and MDR, and RIU controls and monitors its MDRs. 2. Equal level subsystems do not have control over each other, i.e., GNIs do not control each other, RIUs do not control each other, and MDRs do not control each other. 3. An RIU can monitor, through the GNI, its associated diversity site RIU/MDRs, but other equal level subsystems to not monitor each other, i.e., GNIs do not monitor each other, RIUs not associated together do not monitor each other, and MDRs do not monitor each other. 4. Lower level subsystems do not have control over higher level subsystems, i.e., MDR does not control RIU and GNI. 5. An RIU can monitor the GNI associated with that particular Talk Group, but other lower level subsystems do not monitor higher level subsystems, i.e., MDR does not monitor RIU and GNI.	RD Section: 7.2.1; 7.3.1.1
3.2.4.1.1	General Maintenance Requirements	a) The NEXCOM System shall meet the hardware maintenance requirements specified in FAA Order 6000.30C, National Airspace System Maintenance Policy. [RD 5.1.2]	RD Section: 2.2.1; 5.1.3
3.2.4.1.1	General Maintenance Requirements	b) For DSB-AM modes of operation, NEXCOM equipment shall be maintained with the support equipment, test equipment, and tools presently in the FAA inventory. [RD 8.3.1]	RD Section: 2.2.1, 8.3.1
3.2.4.1.1	General Maintenance Requirements	c) Individual Lowest Replaceable Units (LRUs) shall be designed to permit removal and replacement by a single person. [RD 6.2.4]	RD Section: 2.2.1, 6.2.4
3.2.4.2	Access	a) Access to MMC functions shall be by the following means: 1. Local MMC Access (See Section 3.2.4.2.1) 2. Remote MMC Access (See Section 3.2.4.2.2) Note: See Figure B-6 and B-6a of Appendix B for local and remote relationships in the NEXCOM MMC System Hierarchy.	RD Section: 5.1.2
3.2.4.2	Access	b) The NEXCOM System shall permit simultaneous monitoring from all remote and local access points in accordance with 3.2.4a). [RD 5.1.2]	RD Section: 5.1.2

SRD Section	SRD Title	Requirements	Source Document
3.2.4.2	Access	c) Local MMC control access shall automatically inhibit remote control access. [RD 5.1.2]	RD Section: 5.1.2
3.2.4.2	Access	d) The NEXCOM System shall provide multiple privilege levels to control access to the NEXCOM MMC.	RD Section: 7.2.1; 7.3.1.1
3.2.4.2	Access	e) The access privileges associated with each privilege level of the MMC function shall be configurable. [SRD 3.3.4.2; 3.4.6.3.4]	RD Section: 7.2.1; 7.3.1.1
3.2.4.2.1	Local MMC Access	a) The local MMC access point shall provide authorized on-site personnel access to the MMC functions of NEXCOM Subsystems that the on-site personnel is directly connected to, which allows the on-site personnel to carry out diagnostic activities, adjust parameters, and maintain proper operation of the equipment. [RD 5.1.2]	RD Section: 5.1.2; 7.2.1; 7.3.1.1
3.2.4.2.2	Remote MMC Access	a) Remote MMC shall provide authorized personnel access to the MMC functions of indirectly connected NEXCOM Subsystems to carry out diagnostic activities, adjust parameters, and maintain proper operation of the equipment in accordance with 3.2.4a). [RD 5.1.2]	RD Section: 5.1.2; 7.2.1; 7.3.1.1
3.2.4.2.2	Remote MMC Access	b) Remote MMC shall provide the same functionality and capabilities as local MMC functions except for the local audio interface and with the functions performed remotely. [RD 5.1.2]	RD Section: 5.1.2
3.2.4.2.3	MMC Access Security	a) The NEXCOM System shall support the assignment of an unique logon identifier for each logged user.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	b) The NEXCOM System shall authenticate the claimed user’s identity before allowing the user to perform any actions.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	c) When passwords are to be used for authentication, the NEXCOM System shall use strong passwords (i.e. prevent the use of dictionary words).	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	d) The NEXCOM System shall enforce mandatory password changes at set intervals.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	e) The NEXCOM System shall prevent the reuse of passwords on a per user basis.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	f) The NEXCOM System shall execute a defined access control policy.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	g) The NEXCOM System shall enable access authorization management; i.e., the initialization, assignment, and modification of access rights (e.g., read, write, execute) to data objects with respect to (1) group membership (privilege level); and such constraint as port-of-entry.	RD Section 5.1.1; 7.2.1; 7.3.1.1

SRD Section	SRD Title	Requirements	Source Document
3.2.4.2.3	MMC Access Security	h) The NEXCOM System shall enforce separation of duties through it role-based ability to restrict users to specific data objects (MMC functions) and to specific actions on those objects.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	i) The NEXCOM System shall provide resource allocation features having a measure of resistance to resource depletion (mitigate denial of service attacks).	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	j) The NEXCOM System shall temporarily (a configurable period of time) suspend user accounts after a configurable number of consecutive failed logon attempts.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	k) The NEXCOM System shall display a configurable banner page upon login.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.3	MMC Access Security	l) The NEXCOM System shall protect information system security data and functionality from all unauthorized access.	RD Section 5.1.1; 7.2.1; 7.3.1.1
3.2.4.2.4	NEXCOM/NIMS Interfaces	a) The NEXCOM/NIMS interface shall be at the GNIs with the NIMS agent.	RD Section: 5.1.2
3.2.4.2.4	NEXCOM/NIMS Interfaces	b) The NEXCOM/NIMS interface shall provide authentication of the information between NEXCOM and NIMS. [RD 7.3]	RD Section: 5.1.2; 7.2.1; 7.3.1.1
3.2.4.2.4	NEXCOM/NIMS Interfaces	c) The NEXCOM/NIMS interface shall provide integrity assurance of the information between NEXCOM and NIMS. [RD 7.3]	RD Section: 5.1.2; 7.2.1; 7.3.1.1
3.2.4.2.4	NEXCOM/NIMS Interfaces	d) The NIMS proxy agent for the RIUs, MDRs and UHF radios shall be located at the GNI.	RD Section: 5.1.2
3.2.4.3	Service/System/Subsystem Certification Requirements	a) The NEXCOM System shall provide remote monitoring information with sufficient accuracy to verify the correct configuration and operation of each subsystem. [RD 5.1.3; FAA-E-2911 Section 3.2.1.1b; 6000.15C, Chapter 5]	RD Section: 5.1.3; FAA-E-2911 Section: 3.2.1.1b; 6000.15C Chapter 5
3.2.4.3	Service/System/Subsystem Certification Requirements	b) The NEXCOM System shall provide remote monitoring information with sufficient accuracy to verify the correct configuration and operation of the A/G communications service. [RD 5.1.3; FAA-E-2911 Section 3.2.1.1b]	RD Section: 3.2.4.3
3.2.4.4.1	Monitored Parameter Status	a) The system/subsystem level parameters to be monitored shall include the following: 1. Mode of Operation (i.e., 25 kHz DSB-AM, VDL Mode 3, or 8.33 kHz DSB-AM) 2. Ground System Configuration (e.g., Diversity site group operation, VDL Mode 3 System Configuration) 3. RF Link Status [RD 3.3.3; RTCA/DO-224A, 2.4.2]	RD Section: 5.1.3

SRD Section	SRD Title	Requirements	Source Document
		4. Telecommunications Status [RD 3.1.7.1, 3.2.4; SRD 3.2.4.6.2] 5. Subsystem/LRU Status (e.g., Up/Down status for Main/Standby/BUEC elements) [RD 3.1.7] 6. Data Subnetwork Status 7. Timing Source Status 8. Operational status of each Talk Group (e.g. PTT asserted, Main or Standby TX and/or RX selection, etc).	
3.2.4.4.1.1	Performance Status Monitoring	a) The NEXCOM System shall collect and present the workload of system resources. [FAA-E-2911 3.2.1.2.3 a; FAA Order 6000.4]	FAA-E-2911 3.2.1.2.3 a; FAA Order 6000.4
3.2.4.4.1.1	Performance Status Monitoring	b) The NEXCOM System shall collect and present the throughput of system resources. [FAA-E-2911 3.2.1.2.3 b; FAA Order 6000.4]	FAA-E-2911 3.2.1.2.3 b; FAA Order 6000.4
3.2.4.4.1.1	Performance Status Monitoring	c) All NEXCOM System shall collect and present the response time of system resources. [FAA-E-2911 3.2.1.2.3 b; FAA Order 6000.4]	FAA-E-2911 3.2.1.2.3 b; FAA Order 6000.4
3.2.4.4.2	Alerting/Alarming	a) System alarms/alerts shall be sent automatically to: [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e] 1. The local MMC interface 2. The remote MMC interface in accordance with 3.2.4 a)	RD Section: 5.1.3
3.2.4.4.2	Alerting/Alarming	b) A system alarm/alert shall automatically trigger the alarm/alert indicator on the front panel of the associated NEXCOM Subsystems. [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e]	RD Section: 5.1.3
3.2.4.4.2	Alerting/Alarming	c) NEXCOM Subsystems shall forward any alert/alarm received from a remotely monitored NEXCOM Subsystem according to the NEXCOM MMC System Hierarchy discussed in section 3.2.4 a). [RD 5.1.3; FAA-E-2911, 3.2.1.2.1a though 3.2.1.2.1e]	RD Section: 5.1.3

SRD Section	SRD Title	Requirements	Source Document
3.2.4.4.3	MMC Data Logging	a) The NEXCOM System shall log the following: [FAA-E-2911, 3.2.1a through 3.2.1e] 1. Alerts 2. Alarms 3. All changes to system configuration and parameter values along with the unique identifier of the individual making the change 4. All control access attempts and the unique identifier of the individual making the attempt	RD Section: 5.1.2; 5.1.3; FAA-E-2911 Section: 3.2.1
3.2.4.4.3	MMC Data Logging	b) The NEXCOM System shall provide for archiving of log data. [RD 5.1.3; FAA-E-2911, 3.2.1a through 3.2.1e]	RD Section: 5.1.3
3.2.4.4.3	MMC Data Logging	c) The NEXCOM System shall time stamp the data log with the time the information was generated by the originating subsystem. [RD 5.1.3; FAA-E-2911, 3.2.1a through 3.2.1e]	RD Section: 5.1.3
3.2.4.4.3	MMC Data Logging	d) The NEXCOM System shall protect logs against unauthorized deletion and modification, even by system security administrators.	RD Section: 5.1.3
3.2.4.4.3	MMC Data Logging	e) The NEXCOM System shall support centralized security incident reporting.	RD Section: 5.1.3
3.2.4.5	System Control Requirements	a) The NEXCOM System shall have control functions that allow authorized personnel to adjust designated parameters or exercise designated operational controls for specific subsystems(e.g., Frequency Tuning, VDL Mode 3 System Configuration, and Diversity Site Configuration). [RD 5.1.3]	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	a) The NEXCOM System shall include built-in tests and diagnostic functions to detect equipment failures and isolate equipment faults to the LRU level. [RD 5.1.3]	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	b) Diagnostic results and equipment faults shall be available via the local and remote MMC interfaces. [RD 5.1.3]	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	c) The NEXCOM System shall provide recovery features providing a measure of survivability in the face of system failures and insecurities.	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	d) At startup, the NEXCOM System shall perform a self-check for the presence and correct operating capability of the security functions.	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	e) If the self-check of the security functions fails, the NEXCOM System shall generate an alarm.	RD Section: 5.1.3
3.2.4.6.1	Diagnostics and Fault Detection	f) The NEXCOM System shall start only if the self-check of the security functions pass.	RD Section: 5.1.3

SRD Section	SRD Title	Requirements	Source Document
3.2.4.6.1	Diagnostics and Fault Detection	g) If the self-check of the security functions passes, the NEXCOM System shall perform all operations in the secured state (based on the passing of the self-check).	RD Section: 5.1.3
3.2.4.6.2	Telecommunications Monitoring	a) The NEXCOM Subsystems that interface with telecommunications functions shall detect telecommunications (except MDRs analog interface) link failure. [RD 5.1.3; FAA-E-2885]	RD Section: 5.1.3
3.2.4.6.2	Telecommunications Monitoring	b) Upon loss of Telecommunications service for a site/channel, the affected site/channel shall inhibit its RF transmissions automatically. [RD 5.1.3; FAA-E-2885]	RD Section: 5.1.3
3.2.4.6.3	LRU Addressability	a) Every NEXCOM MMC capable LRU shall be uniquely addressable.	RD Section: 5.1.2
3.2.4.7.1	Momentary Interruption Impact	a) The system/subsystem operation shall not be affected by momentary interruptions.	RD Section: 3.2.15.1; 3.2.10.1; 4.6.1; 4.9.1; 10.2.1;
3.2.4.7.2	Power Failure Recovery	a) After a power failure the subsystem shall verify proper operation, and resume operation, if possible.	RD Section: 3.2.15.1; 3.2.10.1; 4.6.1; 4.9.1; 10.2.1;
3.2.4.8	Equipment Hot Swapping	a) The NEXCOM System shall support removal and replacement of LRUs without requiring the NEXCOM Subsystems to be power-down.	RD Section: 3.2.15.1; 3.2.10.1; 4.6.1; 4.9.1; 10.2.1;
3.2.4.9	General Data Interfaces	a) The NEXCOM System shall provide at least three general purpose data interfaces for external devices to communicate between the control and radio sites. [FAA-E-2885]	FAA-E-2885
3.2.4.9	General Data Interfaces	b) This general data interfaces shall have a lower priority than voice, data, or control information.	FAA-E-2885
3.2.5.1.1	Discrete I/O Utilization	a) The NEXCOM System shall support general purpose discrete Inputs and Outputs (I/Os).	FAA-E-2885
3.2.5.1.1	Discrete I/O Utilization	b) The NEXCOM System shall allow for selectable monitoring of discrete I/Os.	FAA-E-2885
3.2.5.1.1	Discrete I/O Utilization	c) When discrete item monitoring is selected/enabled, the NEXCOM System shall generate a user defined MMC message based on I/O state change.	FAA-E-2885
3.2.5.1.1	Discrete I/O Utilization	d) The NEXCOM System discrete I/Os shall be mappable so that an input at a control site can generate at least one corresponding output at a remote site.	FAA-E-2885
3.2.5.1.1	Discrete I/O Utilization	e) The NEXCOM System discrete I/Os shall be mappable so that an input at a remote site can generate at least one corresponding output at a control site.	FAA-E-2885

SRD Section	SRD Title	Requirements	Source Document
3.2.5.1.1	Discrete I/O Utilization	f) The NEXCOM System discrete outputs shall be mappable to alarm/alert messages generated within the NEXCOM System (e.g. Telecommunications link failure status generating a discrete output).	FAA-E-2885
3.2.5.1.1.1	Unused Interfaces	a) LRUs shall have spare I/O pins available for future expansion as subsystem requirements specify. [RD 3.2.14]	RD Section: 3.2.14.1
3.2.5.1.2	Vocoder	a) The vocoder function shall be upgradeable with additional algorithms. [DO 224A, 3.3.5.2.1, pg. 194]	RD Section: 3.2.14.1 RTCA/DO 224A Section: 3.3.5.2.1
3.2.5.2	Software	a) The NEXCOM System shall be upgradeable with new software. [RD Att. 2]	RD Section: 3.2.14.1; Att.2
3.2.5.2.1	Software Upgrade	a) An MMC function shall be provided to upgrade software by uploading new versions of application or operating system software in accordance with section 3.2.4 a). [RD 3.2.14, Att 2]	RD Section: 3.2.14.1; Att.2 SRD Section: 3.2.4a
3.2.5.2.1	Software Upgrade	b) An MCC function shall be provided to delete any version of software or operating system software other than the software in operation.	SRD Section: 3.2.5.2
3.2.5.2.2	Software Version Selection	a) An MMC function shall be provided that allows the selection of different versions of installed software, should more than one version be present.	SRD Section: 3.2.5.2
3.2.5.2.3	Software Version Switch Failure Reversion	a) Upon failure of switching to a new software version, the device shall revert to the previous version of software.	SRD Section: 3.2.5.2
3.2.5.2.4	Software Upload Authentication	a) The NEXCOM System shall provide authentication for all software uploads.	RD Section: 7.2.1; 7.3.1.1
3.2.5.2.4	Software Upload Authentication	b) The NEXCOM System shall provide integrity assurance for all software uploads.	RD Section: 7.2.1; 7.3.1.1
3.2.5.2.4	Software Upload Authentication	c) Software upload attempts shall be reported as system alarms to the MMC system for the following modes: 1. Authentication failure 2. Data Integrity failure 3. Successful uploads	RD Section: 7.2.1; 7.3.1.1
3.2.5.2.4	Software Upload Authentication	d) When software upload failure is detected, the NEXCOM System shall reinitiate software upload only upon receiving a new upload command.	RD Section: 7.2.1; 7.3.1.1

SRD Section	SRD Title	Requirements	Source Document
3.2.5.2.4	Software Upload Authentication	e) When software upload failure is detected, the NEXCOM System shall delete the failed upload from memory.	RD Section: 7.2.1; 7.3.1.1
3.2.6.1	Common Time Conditioning	a) The NEXCOM System shall provide a Timing Source. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 7, 8]	SRD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8
3.2.6.1	Common Time Conditioning	b) The NEXCOM System shall derive system time from the NEXCOM Timing Source per section 3.3.6.1.1. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 7, 8]	Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 7, 8
3.2.6.1	Common Time Conditioning	c) The NEXCOM Timing Source shall accept conditioning from an external Timing Reference. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 7, 8]	Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 7, 8
3.2.6.2	Timing Distribution	a) The NEXCOM System shall allow multiple collocated RIUs to synchronize from a single Timing Source. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]	SRD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8

SRD Section	SRD Title	Requirements	Source Document
3.2.7.1	Reliability	a) The NEXCOM System shall support critical services per NAS-SR-1000.	RD Section: 3.2.1.2 NAS-SR-100
3.2.7.1.1	Single Point of Failure	a) No single failure within the NEXCOM System shall cause loss of User Group communications. [NAS-SR-1000, 3.8.1c]	RD Section: 3.2.1.2 NAS-SR-1000, 3.8.1c
3.2.7.2	Maintainability	a) The NEXCOM System shall support critical services per NAS-SR-1000.	RD Section: 3.2.3.1; NAS-SR-100
3.2.7.3	Availability	a) The NEXCOM System shall support critical services per NAS-SR-1000.	RD Section: 3.2.4.1; NAS-SR-100
3.2.8	Security Measures	a) The NEXCOM System shall provide alerts upon the occurrence of security related events, including attempts to login, attempts of file transfer, and data file modification.	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	b) The NEXCOM System shall detect malicious code and data (e.g. viruses and worms).	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	c) The NEXCOM System shall provide a means to remove detected malicious code and data (e.g. viruses and worms).	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	d) The NEXCOM System shall support the maintenance of detection and removal functions.	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	e) The NEXCOM System shall support Virtual Private Network Technology (e.g. IPSEC and VPNs) to communicate with external systems or via external telecommunications links. [NAS ISS Architecture]	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	f) The NEXCOM System shall generate alerts when file integrity is compromised.	RD Section: 7.3.3.1; 7.4.1
3.2.8	Security Measures	g) The NEXCOM System shall implement screening/firewall/proxy server functionality, as appropriate to meet security requirements.	RD Section: 7.3.3.1; 7.4.1
3.3	NEXCOM System Performance Requirements	a) The NEXCOM System shall meet or exceed the operational coverage area provided by the current analog voice system without degradation of service quality or increase of user workload beyond the workload of the current voice system.	RD Section: 3.2.10.1; 6.3.1
3.3.1.1.1	Power and Grounding	a) The NEXCOM System shall meet the power and grounding requirements of FAA-G-2100G. [RD 4.6.1]	RD Section: 4.6.1; 6.2.5; 8.9.1

SRD Section	SRD Title	Requirements	Source Document
3.3.1.1.1.1	Lightning Protection	a) The NEXCOM System shall provide lightning, transient protection, and harmonic suppression consistent with IEEE/ANSI Standards C62.36-1994, IEEE/ANSI Standards C62.41-1991, IEEE/ANSI Std 519-1992, and IEEE/ANSI Standards C62.31-1987, for the following interfaces where applicable[RD 4.6.1]: 1. Power 2. Telecommunications 3. Antenna	RD Section: 4.3.2
3.3.1.1.2.1	Size	a) Each NEXCOM System Lowest Replaceable Unit (LRU) shall be 19" rack-mountable. [RD 4.2.2]	RD Section: 4.2.2
3.3.1.1.2.1	Size	b) Each NEXCOM LRU shall be no more than 18 inches in depth, including connectors.	RD Section: 4.2.2
3.3.1.1.3	Cable Requirements	a) All NEXCOM cables shall meet the performance requirements specified in the following [RD 4.7]: 1. NFPA Standard 70, National Electrical Code 2. FAA Order 6630.4A, En Route Communications Installation Standards Handbook, Chapter 6, Section 3 3. FAA-C-1217F	RD Section: 4.2.1; 4.7.1; 4.7.2; 4.7.3
3.3.1.1.4.1	Pollution Control Requirements	a) The NEXCOM System shall meet the pollution control requirements specified in Executive Order 12088, Federal Compliance with Pollution Control Standards. [RD 4.3.1]	RD Section: 4.3.1
3.3.1.1.4.1	Pollution Control Requirements	b) The NEXCOM System shall meet the pollution control requirements specified in Executive Order 13101, Greening the Government through Waste Prevention, Recycling, and Federal Acquisition. [RD 4.3.1]	RD Section: 4.3.1
3.3.1.1.4.1	Pollution Control Requirements	c) The NEXCOM System shall meet the pollution control requirements specified in Executive Order 12873, Federal Acquisition, Recycling, and Waste Prevention. [RD 4.3.1]	RD Section: 4.3.1
3.3.1.1.4.1	Pollution Control Requirements	d) The NEXCOM System shall minimize the generation of hazardous wastes as defined in 40 CFR 261, Identification and Listing of Hazardous Wastes. [RD 4.3.1]	RD Section: 4.3.1

SRD Section	SRD Title	Requirements	Source Document
3.3.1.1.4.2	Energy Conservation Requirements	a) The NEXCOM System shall meet the energy conservation requirements specified in Executive Order 13123, Greening the Government Through Efficient Energy Management. [RD 4.3.1]	RD Section: 4.4.1
3.3.1.1.4.2	Energy Conservation Requirements	b) The NEXCOM System shall meet the requirements of Executive Order 12902, Energy Efficiency and Conservation at Federal Facilities. [RD 4.4.1]	RD Section: 4.4.1
3.3.1.1.5.1	Electrical Safety Requirements	a) The NEXCOM System shall meet the personnel safety requirements specified in FAA-G-2100G, paragraphs 3.1, 3.2, and 3.3. [RD 6.2.1 (tailored)]	RD Section: 4.2.1; 4.3.2
3.3.1.1.5.1	Electrical Safety Requirements	b) Facility electrical modifications to support the NEXCOM System shall comply with the requirements of NFPA 70. [NFPA 70]	RD Section: 4.2.1; 4.3.2
3.3.1.1.5.2	Hazardous Materials	a) The NEXCOM System shall be free of asbestos, polychlorinated biphenyls (PCBs), lead, and class 1 ozone depleting substances. [RD 4.8.2]	RD Section: 4.2.1; 4.8.1; 4.3.2; 6.2.3; 8.0
3.3.1.1.5.2	Hazardous Materials	b) The NEXCOM System shall limit personnel exposure to hazardous materials to the levels permitted by 29 CFR 1910 Subpart Z. [29 CFR 1910, Subpart Z]	RD Section: 4.8.1; 4.3.2; 6.2.3
3.3.1.1.5.3	Personnel Safety Requirements	a) The NEXCOM System shall comply with the requirements of 29CFR Parts 1910 and 1926. [RD 6.2.3]	RD Section: 6.2.1; 6.2.2; 6.2.3
3.3.1.1.5.3	Personnel Safety Requirements	b) The NEXCOM System shall comply with FAA Order 3900.19B, chapter 1, paragraphs 7e and 7l. [RD 6.2.2]	RD Section: 6.2.1; 6.2.2; 6.2.3
3.3.1.1.5.4	Seismic Safety	a) New construction supporting the NEXCOM System shall be in accordance with 49 CFR Part 41. [DOT implementation of EO 12699] [3.8.4.4.1.2]	RD Section: 4.3; DOT implementation of EO 12699 Section: 3.8.4.4.1.2
3.3.1.1.5.4	Seismic Safety	b) The NEXCOM System elements installed in existing facilities shall be in accordance with FEMA-74. [DOT-SS-98-01 - DOT policy for EO 12941]	RD Section: 4.3; DOT-SS-98-01 - DOT policy for EO 12941
3.3.1.1.5.5	Equipment Safety	a) Connecting cables consistent with proper operation to or disconnecting cables from equipment in the NEXCOM System while the equipment is powered and the system is in operation shall not cause damage to any equipment in the NEXCOM System.	RD Section: 4.7

SRD Section	SRD Title	Requirements	Source Document
3.3.1.2.1	Radio Frequency Interference and Electromagnetic Interference Requirements	a) The NEXCOM System shall meet the RFI/EMI requirements specified in FAA-G-2100G, section 3.3.2.	RD Section: 3.2.13.1; 3.3.1.2.1
3.3.2.1	VDL Mode 3 Standardization	a) The NEXCOM System shall meet the VDL Mode 3 performance requirements for ground systems specified in RTCA DO-224A.	SRD Section: 3.2.2.1
3.3.2.1	VDL Mode 3 Standardization	b) The NEXCOM System shall meet United States regulatory performance requirements specified in FCC, NTIA, etc..	SRD Section: 3.2.2.2
3.3.2.1	VDL Mode 3 Standardization	c) When there are conflicts between a) and b) above, the more stringent requirement shall take precedence.	SRD Section: 3.2.2.3
3.3.2.2	25 kHz DSB-AM Standardization	a) The NEXCOM System shall meet the 25 kHz DSB-AM performance requirements specified in FAA-P-2883 and FAA-P-2884.	SRD Section: 3.2.2.2
3.3.2.3	8.33 kHz DSB-AM Standardization	a) The NEXCOM System shall meet the 8.33 kHz DSB-AM performance requirements specified in ICAO Annex 10 and ETSI EN-300-676.	SRD Section: 3.2.2.3
3.3.3.1.1	Voice Channels	a) The NEXCOM System shall support a control facility with at least [350] voice channels per control facility.	SRD Section: 3.2.3.1.1
3.3.3.1.2	Voice Quality/Intelligibility	a) The NEXCOM System shall not degrade the voice quality/intelligibility in a statistically inconsistent from the current DSB-AM mode.	RD Section: 3.2.6.1
3.3.3.1.2.1	Audio Clipping	a) During normal operation, the NEXCOM System shall not truncate the voice signal received or transmitted.	RD Section: 3.2.8.1
3.3.3.1.2.1	Audio Clipping	b) During voice preemption operation and the channel is busy, the NEXCOM System shall allow truncation of the voice signal received and transmitted.	SRD Section: 3.2.3.1.2.1
3.3.3.1.3.1	Uplink Path	a) The uplink audio throughput delay shall be no greater than 145 milliseconds in analog voice mode. [RD 3.2.7.1]	RD Section: 3.2.7.1; SRD Section: 3.2.3.1.3.1; Appendix F
3.3.3.1.3.1	Uplink Path	b) The uplink audio throughput delay shall be no greater than 173 milliseconds in digital voice mode. [RD 3.2.7.1]	RD Section: 3.2.7.1; SRD Section: 3.2.3.1.3.1; Appendix F
3.3.3.1.3.2	Downlink Path	a) The downlink audio throughput delay shall be no greater than 153 milliseconds in analog voice mode. [RD 3.2.7.1]	RD Section: 3.2.7.1; SRD Section: 3.2.3.1.3.2; Appendix F

SRD Section	SRD Title	Requirements	Source Document
3.3.3.1.3.2	Downlink Path	b) The downlink audio throughput delay shall be no greater than 61 milliseconds in digital voice mode. [RD 3.2.7.1]	RD Section: 3.2.7.1; SRD Section: 3.2.3.1.3.2; Appendix F
3.3.3.2.1.1	Router Network Size	a) The NEXCOM System shall use between 2 and 48 A/G Routers.	SRD Section: 3.2.3.2.1.1
3.3.3.2.1.2	Minimization of ATN Port Usage	a) The NEXCOM System shall provide a data switching function to concentrate GNI connectivity to a limited number of A/G Router ports.	SRD Section 3.3.3.2.1.1
3.3.3.2.1.3	Subnetwork Integrity	a) The NEXCOM subnetwork shall guarantee a probability of undetected packet error of less than 10-9. [ICAO Doc 9705]	ICAO Doc 9705
3.3.3.2.1.4	Subnetwork Transit Delay	a) The NEXCOM System shall successfully communicate 95% of the packets from one end of the subnetwork to the other based on the required class of service per the following table. [ICAO Doc 9705, Table 5.2-2]	ICAO Doc 9705 Table 5.2-2
3.3.3.2.1.4.1	Traffic Loading	a) The NEXCOM System shall support the traffic identified in Table 3-2 at the specified performance level.	ICAO Doc 9705 Table 5.2-2
3.3.3.3	Continuous Broadcast	a) The NEXCOM System shall operate at up to 100 percent duty cycle in DSB-AM.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1
3.3.3.3	Continuous Broadcast	b) The NEXCOM System shall operate at up to 79.5 percent duty cycle in VDL Mode 3.	RD Section: 3.2.15.1; 3.2.10.1; 10.2.1
3.3.3.4.3	Subnetwork Leave Event Issuance Delay	a) The NEXCOM System shall issue Leave Events to the A/G router based on the required class of service per the following table 95% of the time, measured from when the connection is lost to when the Leave Event is sent to the A/G router. Different performance is specified depending on whether or not data traffic is present. [ICAO Doc 9705, Table 5.2-2]	ICAO Doc 9705 Table 5.2-2
3.3.3.5	Ground Station Operations	a) The NEXCOM System shall support up to four User Groups on the same VDL Mode 3 frequency assignment.	SRD Section: 3.2.3.5
3.3.3.5	Ground Station Operations	b) Each NEXCOM Talk Group's voice communications resources shall be controllable independent from all other Talk Groups' voice communications resources.	RD Section: 3.1.1.1; SRD Section: 3.2.3.5
3.3.3.5	Ground Station Operations	c) The NEXCOM System shall support operation of multiple ground sites for one User Group in a sector having two to twelve diversely located RCFs.	SRD Section: 3.2.3.5

SRD Section	SRD Title	Requirements	Source Document
3.3.3.5	Ground Station Operations	d) The NEXCOM System shall provide uplink M beacons to all aircraft within a service volume to maintain timing state TS1 as defined in DO224A.	SRD Section: 3.2.2.1
3.3.3.6.1	Push-to-Talk Transmitter Keying	a) For VDL Mode 3 mode and DSB-AM modes of operation using the PCM interface, the NEXCOM System shall transmit/cease transmit voice audio within 175 ms of the arrival of the PTT/PTT Release signal at the NEXCOM/VSCE interface for 99.9% of the events. [RD 3.2.7.1; FAA-E-2885, 3.2.3.2.2.1]	RD Section: 3.1.4.1
3.3.3.6.1	Push-to-Talk Transmitter Keying	b) For DSB-AM modes of operation using an analog audio interface, the NEXCOM System shall transmit/cease transmit RF to 90% output power within 175 ms of the arrival of the PTT/PTT Release signal at the NEXCOM/VSCE interface for 99.9% of the events. [RD 3.2.7.1, 10.2.1.1; FAA-e-2885, 3.2.3.2.2.1]	RD Section: 3.1.4.1
3.3.3.6.1	Push-to-Talk Transmitter Keying	c) In DSB-AM modes of UHF radio operation using the analog audio interface, the NEXCOM System shall indicate to the NEXCOM/VSCE interface the confirmation of PTT activation by the transmitter within 350 ms for 99.9% of the PTT confirmation events. [RD 10.2.1.1; FAA-E-2885, 3.2.3.2.2.1.1]	RD Section: 3.1.1.4; 3.1.4.; SRD Section: 3.2.3.6.1
3.3.3.6.1	Push-to-Talk Transmitter Keying	d) The NEXCOM System shall indicate to the NEXCOM/VSCE interface the confirmation of audio transmission within 350 ms for 99.9% of the PTT confirmation events. [RD 10.2.1.1; FAA-E-2885, 3.2.3.2.2.1.1]	RD Section: 3.1.1.4; 3.1.4.; SRD Section: 3.2.3.6.1
3.3.3.6.2	Preemption of Aircraft Voice Transmissions	a) The NEXCOM System shall initiate transmission of a voice preemption signal in the next two scheduled uplink M-burst opportunities for the associated primary and backup radio sites when the condition of simultaneous presence of a voice preemption control signal and a PTT occurs at the NEXCOM/VSCE interface.	SRD Section: 3.2.3.6.2; 3.2.2.1
3.3.3.6.2	Preemption of Aircraft Voice Transmissions	b) When simultaneous presence of a voice preemption control signal and a PTT at the NEXCOM/VSCE interface occurs more than 50 ms prior to the next scheduled uplink M-burst for the selected pair of primary and backup radio sites, the voice preemption signal shall be transmitted in that uplink M-burst for 99.9% of the override events.	SRD Section: 3.2.3.6.2; 3.2.2.1
3.3.3.6.2	Preemption of Aircraft Voice Transmissions	c) The transmission of voice preemption signal shall continue on all scheduled uplink M-bursts for the duration of simultaneous presence of a preemption control signal and a PTT.	SRD Section: 3.2.3.6.2; 3.2.2.1
3.3.3.6.2	Preemption of Aircraft Voice Transmissions	d) When configured for diversity site group operation and during an attempted preemption, the NEXCOM System shall disable current downlink transmissions with the next uplink M-burst opportunity.	SRD Section: 3.2.3.6.2; 3.2.2.1

SRD Section	SRD Title	Requirements	Source Document
3.3.3.6.2	Preemption of Aircraft Voice Transmissions	e) The NEXCOM System shall provide, back to the NEXCOM/VSCE interface, confirmation of voice preemption activation within 350 ms of its transmission for 99.9% of the events.	SRD Section: 3.2.3.6.2; 3.2.2.1
3.3.3.6.3	Squelch Break	a) The NEXCOM System shall indicate to the NEXCOM/VSCE interface squelch breaks in the receiver within 125 ms for 99.9% of the squelch break indication events.	SRD Section: 3.2.3.6.3
3.3.3.6.4	Received Audio Muting	a) The NEXCOM System shall provide receive path muting/unmuting within 105 ms for 99.9% of the muting/unmuting events. [FAA-E-2885, 3.2.3.2.2.3]	FAA-E-2885 Section: 3.2.3.2.2.3
3.3.3.6.4	Received Audio Muting	b) The NEXCOM System shall provide receive path muting/unmuting confirmation to the NEXCOM/VSCE interface within 350 ms for 99.9% of the receive path muting/unmuting confirmation events. [FAA-E-2885, 3.2.3.2.2.3.1]	FAA-E-2885 Section: 3.2.3.2.2.3.1
3.3.3.6.4.1	PTT Mute/Attenuation	a) The audio attenuation shall be configurable from of 0, 15, or 20 dB.	SRD Section 3.2.3.6.4.1; FAA-E-2885
3.3.3.6.4.1	PTT Mute/Attenuation	b) The audio attenuation delay shall be configurable in duration for up to 600 ms (0 to 600 ms in 10 ms increments).	SRD Section 3.2.3.6.4.1; FAA-E-2885
3.3.3.6.5	Ground Radio Resource Selection and Switching	a) The NEXCOM System shall switch radio resources (e.g., Main/Standby Select/Deselect, or BUEC Select/Reset as necessary) within 100 ms of receipt of the signal from the NEXCOM/VSCE interface for 99.9% of the radio resource selection events. [FAA-E-2885, 3.2.3.2.2.2]	SRD Section: 3.2.3.6.5; FAA-E-2885 Section: 3.2.3.2.2.2
3.3.3.6.5	Ground Radio Resource Selection and Switching	b) The NEXCOM System shall confirm radio resource selection (e.g., Main/Standby Select Confirmation or BUEC Ready) within at most 250 ms from the time of switching for 99.9% of the radio resource selection events. [FAA-E-2885, 3.2.3.2.2.2.1]	RD Section: 3.1.1.4; SRD Section: 3.2.3.6.5.1; FAA-E-2885 Section: 3.2.3.2.2.2.1
3.3.3.6.5.2	Automatic Radio Switching	a) The NEXCOM System shall switch from the failed radio to the operational alternate radio and be ready to operate over the alternate radio within 30 ms after detection of the radio failure.	SRD Section: 3.2.3.6.5.2
3.3.3.6.6	Channel Busy Signal Performance	a) The NEXCOM latency for the channel busy indicator shall be at most 125 ms for 99.9% of the channel busy events.	SRD Section: Appendix F

SRD Section	SRD Title	Requirements	Source Document
3.3.3.6.6	Channel Busy Signal Performance	b) The NEXCOM latency for the VHF/UHF Lockout indicator shall be at most 125 ms for 99.9% of the lockout events. [RD 3.1.6.1; SRD 3.2.4.2a]	SRD Section: Appendix F
3.3.3.7	Ground Stuck Microphone Correction	a) The Ground Stuck Microphone timeout shall be configurable up to 5 minutes. [RD 3.3.1, 3.3.2; DO 224A, 3.3.2.1.1.1]	RD Section: 3.3.1; 3.3.2; RTCA/DO-224A section 3.3.2.1.1.1; SRD Section: 3.2.2.1
3.3.3.8.1	Telecommunications Delay and Delay Variations	a) The NEXCOM System shall operate when the Telecommunications one-way delay is up to 600 ms.	FAA-E-2885; ANICS; SRD Section: 3.2.3.8.1
3.3.3.8.1	Telecommunications Delay and Delay Variations	b) The NEXCOM System shall operate with transfer delay variations.	FAA-E-2885; SRD Section: 3.3.3.8.1
3.3.3.8.1	Telecommunications Delay and Delay Variations	c) The NEXCOM System transfer delay shall be minimized based on the characteristics of the Telecommunications media.	FAA-E-2885; SRD Section: 3.3.3.8.1
3.3.3.8.2	Telecommunications Restoration Performance	a) The restoration time, defined to be the combined time to detect the link failure, and to restore operations, shall be 6 seconds or less. [NAS-SR-1000]	FAA-E-2885; NAS-SR-1000
3.3.3.8.2	Telecommunications Restoration Performance	b) For telecommunications service interruption of less than 1 second in duration, the NEXCOM System shall restore the communications service within 120 milliseconds after the condition that caused the service interruption is removed.	FAA-E-2885
3.3.3.8.2	Telecommunications Restoration Performance	c) When a backup telecommunications link is available, the NEXCOM System shall restore operation from the primary telecommunications link to the backup telecommunications link in 3 seconds or less after detection of the primary telecommunications service failure.	FAA-E-2885
3.3.3.8.2	Telecommunications Restoration Performance	d) The NEXCOM System shall switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the primary telecommunications link is restored when the PTT is not asserted, without loss of data.	FAA-E-2885
3.3.3.8.2	Telecommunications Restoration Performance	e) The NEXCOM System shall switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the PTT is de-asserted upon restoration of the primary telecommunications link , without loss of data.	FAA-E-2885

SRD Section	SRD Title	Requirements	Source Document
3.3.3.8.2.1	Standby Telecommunications Restoration Performance	a) When a backup telecommunications link is available and the system is in the standby telecommunications backup configuration, the NEXCOM System shall restore operation from the primary telecommunications link to the backup telecommunications link in 1 second or less after detection of the primary telecommunications service failure.	SRD Section: 3.2.3.8.2.1; FAA-E-2885
3.3.3.8.2.1	Standby Telecommunications Restoration Performance	b) When configured for standby telecommunications backup after the primary link has failed, the NEXCOM System shall switch its operation from the backup telecommunications link to the primary telecommunications link within 3 seconds after the primary telecommunications link is restored, without loss of data.	SRD Section: 3.2.3.8.2.1; FAA-E-2885
3.3.4.1.1	LRU Maintenance	a) Maintenance of individual LRUs shall meet the requirements specified in FAA-G-2100G, Section 3.1.2.	FAA-G-2100G
3.3.4.1.2	Non-Interference MMC	a) The NEXCOM MMC function shall not degrade system performance. [FAA Order 6000.30C, Section 11e(4); FAA-E-2911, Section 3.2.1c]	FAA Order 6000.30C Section: 11e(4); FAA-E-2911 Section: 3.2.1
3.3.4.1.2	Non-Interference MMC	b) The failure of the MMC function shall not degrade the NEXCOM System operation.	FAA Order 6000.30C Section: 11e(4); FAA-E-2911 Section: 3.2.1
3.3.4.2	MMC Access Security	a) The NEXCOM System shall provide at least 8 privilege levels for access to the NEXCOM MMC. [SRD 3.2.4.2, 3.4.6.3.4]	RD Section: 5.1.2; 7.2.1; 7.3.1.1 SRD 3.2.4.2; 3.4.6.3.4
3.3.4.4.1	Monitored Parameter Status	a) All data provided in response to maintenance or monitoring inquiries shall be less than two seconds old on average at the time of response, with a maximum of 4 seconds. [RD 5.1.2; FAA-E-2911, 3.2.3b]	RD Section: 5.1.2; FAA-E-2911 Section: 3.2.3
3.3.4.4.1	Monitored Parameter Status	b) The response shall be sent within 2 seconds average, 4 seconds maximum, after receipt of the inquiry. The time is measured from the time the managed subsystem receives the last byte of the data request to the time that the managed subsystem transmits the first byte of the response. [RD 5.1.2; FAA-E-2911, 3.2.3c]	RD Section: 5.1.2; FAA-E-2911 Section: 3.2.3
3.3.4.4.2	Alerting/Alarming	a) All data provided in alerts and alarms shall be less than two seconds old on average at the time of generation, with a maximum of 4 seconds. [RD 5.1.2; FAA-E-2911, 3.2.3b]	RD Section: 5.1.2; FAA-E-2911 Section: 3.2.3

SRD Section	SRD Title	Requirements	Source Document
3.3.4.4.3	MMC Data Logging	a) The NEXCOM System shall have 30 days of storage capacity for data logging entries to support diagnostics, and configuration management, without archival. [FAA-E-2911, 3.2.1a through 3.2.1e].	FAA-E-2911 Section: 3.2.1
3.3.4.4.3	MMC Data Logging	b) New data shall over-write the oldest user unprotected data when the storage capacity is reached for non-archived data. [FAA-E-2911, 3.2.1a through 3.2.1e]	FAA-E-2911 Section: 3.2.1
3.3.4.4.3	MMC Data Logging	c) The NEXCOM System shall automatically archive log entries that are older than 25 days. [FAA-E-2911, 3.2.1a through 3.2.1e]	FAA-E-2911 Section: 3.2.1
3.3.4.4.3	MMC Data Logging	d) The NEXCOM System archival function shall not over-write existing log data.	RD Section: 5.1.2; 5.1.3
3.3.4.5	System Control Requirements	a) The subsystem shall complete the task of executing a change of a MMC parameter command within 1-second average, 3 seconds maximum, after receiving the command. [RD 5.1.2; FAA-E-2911, 3.2.3d]	RD Section: 5.1.2; FAA-E-2911 Section: 3.2.3
3.3.4.5.1	Frequency Range	a) The NEXCOM System shall provide communications services in the range of 112 -137 MHz.	RD Section: 3.2.9.1; 5.3.2
3.3.4.5.1	Frequency Range	b) The NEXCOM System shall provide selectable lock out of the band from 112-117.975 MHz to prevent accidental tuning into the band prior to reallocation of portions of or the entire band for ATC use.	RD Section: 3.2.9.1; 5.3.2
3.3.4.5.2	RF Power Output	a) The RF output power of the NEXCOM System shall be adjustable from 2 to 50 watts (33 dBm to 47 dBm).	RD Section: 3.2.10.1; 6.3.1
3.3.4.7	System Startup	a) The NEXCOM System shall be operational within 5 minutes of applying power to the system components (subsystems).	SRD Section: 3.2.4.7
3.3.4.7	System Startup	b) Each NEXCOM Subsystem shall be operational within 5 minutes of applying power.	SRD Section: 3.2.4.7
3.2.4.9	General Data Interfaces	a) The NEXCOM System shall interface at up to 9,600 bps communications on each of the general data interfaces. [FAA-E-2885]	FAA-E-2885
3.2.4.9	General Data Interfaces	b) The NEXCOM System shall provide an aggregate rate of at least 1,200 bps for all of the general data interfaces.	FAA-E-2885
3.2.4.9	General Data Interfaces	c) The general data interfaces shall not degrade system performance.	FAA-E-2885
3.3.5.1	System Growth Margin	a) The system will be implemented with excess computational capacity such that the initial utilization of system for both voice and data resources does not exceed the levels in the following paragraphs. [RD 3.2.14]	RD Section: 3.2.14

SRD Section	SRD Title	Requirements	Source Document
3.3.5.1.1	Discrete I/O Utilization	a) The NEXCOM System shall provide an output state change w/in 500 msec of the state change at the input where 99.9% of the discrete I/Os state change event, and so configured.	SRD Section: 3.2.5.1.1FAA-E-2885
3.3.5.1.1.1	Unused Interfaces	a) Internal and external interfaces, which are not required for operations, shall not degrade system operations or performance, regardless whether they are activated or deactivated, open or terminated.	SRD Section 3.3.5.1
3.3.5.1.1.1	Unused Interfaces	b) Unused interfaces, which are deactivated from operational use, shall not degrade system operations or performance, regardless whether they are open or terminated.	SRD Section 3.3.5.1
3.3.5.1.1.2	NEXCOM System Throughput	a) I/O throughput provided shall have room for future expansions. [RD 3.2.14]	RD Section: 3.2.14
3.3.5.1.1.2	NEXCOM System Throughput	b) The NEXCOM System shall operate with full occupancy of all voice and data slots. [RD 3.2.12.1]	RD Section: 3.2.12.1
3.3.5.2.1.1	Random Access Memory	a) The subsystems, as initially implemented, shall utilize less than 50% of the total available RAM. [RD 3.2.14]	RD Section: 3.2.14
3.3.5.2.1.2	Non-Volatile Memory	a) The subsystems, as initially implemented, shall utilize less than 50% of the total available non-volatile memory. [RD 3.2.14]	RD Section: 3.2.14
3.3.5.2.2	Processor Utilization	a) The utilization of all programmable processors shall not exceed 50 % of the maximum capacity of the device(s) as initially implemented. [RD 3.2.14]	RD Section: 3.2.14
3.3.6.1.1	Timing Accuracy	a) System time, maintained by the RIU, shall be maintained within ± 10 microseconds (ms) of the Timing Source. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]	RD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8
3.3.6.1.1	Timing Accuracy	b) GNIs shall maintain system time to within ± 10 microseconds (ms) of the RIU. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]	RD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8

SRD Section	SRD Title	Requirements	Source Document
3.3.6.1.1	Timing Accuracy	c) MDRs shall maintain system time to within ± 10 microseconds (ms) of the RIU. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]	RD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8
3.3.6.1.1	Timing Accuracy	d) The Timing Source shall maintain timing within ± 3 microseconds (ms) of the Timing Reference.	SRD Section: 3.2.2.2
3.3.6.2	Timing Drift	a) With the loss of external Timing Reference conditioning, the Timing Source shall maintain system timing for at least 30 days without degrading system operation due to timing. [Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8]	RD Section: 3.2.2.1; Manual on VDL Mode 3 Technical Specifications 5.5; Manual on Implementation of VDL Mode 3 Section 7, 8
3.3.6.3	Timing Standard	a) The Timing Source shall be aligned with UTC on 6 January 1980. [Manual on VDL Mode 3, Technical Specifications 5.5.2.1.5]	Manual on VDL Mode 3, Technical Specifications Section: 5.5.2.1.5
3.3.7.1.1	NEXCOM Mean Time Between Outages (MTBO)	a) The MTBO of the NEXCOM Subsystem at an RCAG shall be greater than or equal to 19,996 hours. [RD 3.2.2.2]	RD Section: 3.2.2.2
3.3.7.2.1	NEXCOM Mean Time to Restore (MTTR)	a) The NEXCOM RCAG MTTR, as defined by FAA Order 6040.15C, par. 702f [TBR], shall be less than or equal to 0.5 hour. [RD 3.2.3.1]	RD Section: 3.2.3.1
3.3.7.2.2	Periodic Maintenance	a) The equipment shall require on-site periodic maintenance no more than once per year. [RD 3.2.5.1]	RD Section: 3.2.5.1; 3.2.5.2; 3.2.5.3
3.3.7.2.2	Periodic Maintenance	b) Periodic maintenance tasks shall require no more than one person to accomplish. [RD 3.2.5.2]	RD Section: 3.2.5.1; 3.2.5.2; 3.2.5.3
3.3.7.2.2	Periodic Maintenance	c) Time to complete periodic maintenance tasks shall be equal to or less than existing equipment and require no more than 12 staff hours per year in accordance with NAS-SS-1000, Volume I, par. 3.2.3.2. [RD 3.2.5.3]	RD Section: 3.2.5.1; 3.2.5.2; 3.2.5.3

SRD Section	SRD Title	Requirements	Source Document
3.3.7.3.1	Voice Service Availability	a) The NEXCOM voice service availability, as defined by FAA Order 6040.15, par. 702c, shall be 0.99999 or greater. [RD 3.2.4.1]	RD Section: 3.2.4.1
3.3.7.3.2	Data Service Availability	a) The NEXCOM data service availability, as defined by FAA Order 6040.15, par. 702c, shall be 0.99999 or greater. [NAS-SR-1000, 3.8.1C]	NAS-SR-1000, 3.8.1c
3.3.7.3.3	Equipment Availability	a) The NEXCOM System equipment shall have an inherent availability of .999975 or greater in accordance with NAS-SS-1000, Volume I, par. 3.2.4. [RD 3.2.4.2]	RD Section: 3.2.4.2 NAS-SS-1000, V1, Section 3.2.4
3.4.1.1	MDR Sustainment Operation	a) The NEXCOM MDR subsystems shall meet the functional requirements specified in the following: 1. FAA-P-2883, Purchase Description, VHF/UHF Air/Ground Communications Receiver 2. FAA-P-2884, Purchase Description, VHF/UHF Air/Ground Communications Transmitter	FAA-P-2883; FAA-P-2884
3.4.1.2	MDR Subsystem Functions	a) MDR transmitter subsystems shall be capable of providing the functions listed in Table 3-4.	SRD Section: 3.2.2.1; RTCA DO-224a
3.4.1.2	MDR Subsystem Functions	b) The MDR receiver shall provide the functions listed in Table 3-5.	SRD Section: 3.2.2.1; RTCA DO-224a
3.4.1.3	MDR Subsystem Interfaces	a) The MDR Transmitter and Receiver units shall have the following interfaces: 1. MDR/RIU Pulse Code Modulation (PCM) voice interface 2. MDR/RIU digital interface 3. MDR/MDT interface 4. MDR/RCE interface 5. MDR/Antenna interface 6. MDR/MDR RF-to-RF interface	RD Section: 5.1.3; SRD Section: 3.2.2; FAA-E-2885
3.4.1.4	MDR Human Interfaces	a) Each MDR transmitter shall include an on/off power switch.	RD Section: 6.1.1; 6.1.2
3.4.1.4	MDR Human Interfaces	b) Each MDR transmitter shall include a front panel display of the frequency, equipment state, and mode of operation.	RD Section: 6.1.1; 6.1.2

SRD Section	SRD Title	Requirements	Source Document
3.4.1.4	MDR Human Interfaces	c) Each MDR receiver shall include an on/off power switch.	RD Section: 6.1.1; 6.1.2
3.4.1.4	MDR Human Interfaces	d) Each MDR receiver shall include a front panel display of the frequency, equipment state, and mode of operation.	RD Section: 6.1.1; 6.1.2
3.4.1.5	MDR System Timing	a) The MDR shall derive all necessary VDL Mode 3 TDMA timing using the information received from the RIU.	SRD Section: 3.6.2; 3.4.2.1.3.8
3.4.1.6	MDR Reliability/Maintainability	a) The MDR shall support critical services per NAS-SR-1000.	SRD Section: 3.2.7.1
3.4.2.1.1	RIU Physical Layer Functions	a) The RIU shall encode and decode Reed-Solomon (72, 62) codewords for VDL Mode 3 data burst operation per RTCA DO-224A, Section 3.3.1.3.3.3. [SRD 3.2.1.3]	SRD 3.2.1.3
3.4.2.1.2	RIU Media Access Control (MAC) Functions	a) The RIU shall implement the ground portion of the VDL Mode 3 MAC sublayer for voice, data and management functions as defined in RTCA DO-224A section 3.3.2.1, except for requirements related to system configurations 3T, 3S and 2S1X. [SRD 3.2.1.3]	SRD Section: 3.2.1.3
3.4.2.1.2	RIU Media Access Control (MAC) Functions	b) The RIU shall be upgradeable to support all other VDL Mode 3 system configurations.	SRD Section: 3.2.2.1
3.4.2.1.3.1	RIU Subsystem PCM Voice Operation	a) The RIU shall use Pulse Code Modulation (PCM) to communicate audio with the MDR transmitter and receiver for DSB-AM modes of operation.	SRD Section: 3.2.2.2
3.4.2.1.3.2	RIU Subsystem Vocoder Operation	a) The RIU shall vocode audio between the GNI and the DSB-AM transmitter and receiver.	SRD Section: 3.2.2.1
3.4.2.1.3.2	RIU Subsystem Vocoder Operation	b) The RIU shall support both normal voice and downlink truncated voice data rates. [SRD 3.2.1.3]	SRD Section: 3.2.1.3
3.4.2.1.3.3	Simultaneous Downlink UHF/VHF Voice	a) When the RIU is supporting DSB-AM modes of operation for VHF, the RIU shall conference/sum audio received from the selected and unmuted VHF and UHF receivers.	SRD Section: 3.2.2
3.4.2.1.3.3	Simultaneous Downlink UHF/VHF Voice	b) When downlink activity is present on both VHF and UHF Talk Groups, the RIU shall be configurable to communicate both audio conversations to the GNI.	SRD Section: 3.2.2
3.4.2.1.3.3	Simultaneous Downlink UHF/VHF Voice	c) If a downlink UHF voice reception begins while a downlink VDL Mode 3 voice reception is in progress, the RIU shall notify the GNI of the UHF reception and drop the UHF voice reception until the VDL Mode 3 downlink voice reception terminates.	SRD Section: 3.2.2

SRD Section	SRD Title	Requirements	Source Document
3.4.2.1.3.3	Simultaneous Downlink UHF/VHF Voice	d) If a downlink VHF VDL Mode 3 voice reception begins while a downlink UHF voice reception is in progress, the RIU shall send the aircraft ID associated with the VDL Mode 3 reception to the GNI and drop the VDL Mode 3 voice reception until the UHF downlink voice reception terminates.	SRD Section: 3.2.2
3.4.2.1.3.4	RIU Subsystem Mode 3 Data Operation	a) For VDL Mode 3 data operation, the RIU shall schedule data access as per the Manual for the Implementation of VDL Mode 3, Section 4.9.	Manual for the Implementation of VDL Mode 3: Section 4.9.
3.4.2.1.3.4	RIU Subsystem Mode 3 Data Operation	b) The RIU shall provide means whereby the maintenance personnel can prevent the use of the Main or Standby resources for data operation.	SRD Section: 3.2.4.1.1
3.4.2.1.3.4	RIU Subsystem Mode 3 Data Operation	c) Upon enabling or disabling of the maintenance restriction of b), the RIU shall maintain data flow without interruption.	SRD Section: 3.2.4.1.1
3.4.2.1.3.5	RIU Link Management Entity (LME) Functions	The RIU shall provide the following LME functions as defined in RTCA DO-224A, Section 3.3.2.3: [SRD 3.2.1.3] 1. Net Initialization 2. Net Entry 3. Link Maintenance (e.g., polling) 4. Link Release 5. Expedited Recovery	SRD Section: 3.2.1.3; RTCA DO-224A Section 3.3.2.3
3.4.2.1.3.5	RIU Link Management Entity (LME) Functions	b) The RIU shall be upgradeable to support all system configurations.	SRD Section: 3.2.2
3.4.2.1.3.6	RIU Subsystem Mode 3 DLS Functions	a) The RIU shall provide the DLS ACK processing and priority queuing functions as defined in RTCA DO-224A, Section 3.3.2.2. [SRD 3.2.1.3]	SRD Section 3.2.1.3 RTCA/DO 224A Section 3.3.2.2
3.4.2.1.3.6	RIU Subsystem Mode 3 DLS Functions	b) The RIU shall perform error detection and address identification (ID) on all DLS frames received from an MDR receiver as defined in RTCA DO-224A, Section 3.3.2.2.1. [SRD 3.2.1.3]	SRD Section: 3.2.1.3; RTCA DO-224A Section 3.3.2.2.1
3.4.2.1.3.7	RIU Local Maintenance, Monitoring and Control	a) The RIU shall interface to a local Maintenance Data Terminal to allow local control of the RIU. [SRD 3.4.6.1]	SRD Section 3.4.6.1

SRD Section	SRD Title	Requirements	Source Document
3.4.2.1.3.7	RIU Local Maintenance, Monitoring and Control	b) The RIU shall allow the locally connected MDT to remotely control all attached MDRs and all attached UHF radios. [SRD 3.4.6]	SRD Section: 3.4.6
3.4.2.1.3.7	RIU Local Maintenance, Monitoring and Control	c) The RIU shall only accept authenticated control commands from a MDT.	RD Section: 7.2.1; 7.3.1.1
3.4.2.1.3.7	RIU Local Maintenance, Monitoring and Control	d) The RIU shall allow an MDT to access all RIUs at the facility from a common connection point.	FAA-E-2885
3.4.2.1.3.7	RIU Local Maintenance, Monitoring and Control	e) The RIU shall allow monitoring of its User Group resources in the GNI and its backup sites from its MDT ports.	SRD Section: 3.2.4
3.4.2.1.3.7.1	RIU Front Panel Control and Monitoring	a) The RIU shall provide front-panel access to limited MMC capabilities to include: 1. Local Audio provision with independent volume control and slot selection 2. Status and Configuration Display	RD Section: 6.1.1; 6.1.2
3.4.2.1.3.8	RIU System Timing Source	a) The RIU shall provide timing to the MDR transmitters and receivers.	SRD Section: 3.2.6.2
3.4.2.1.3.8	RIU System Timing Source	b) The RIU shall provide timing to the GNI.	SRD Section: 3.2.6.2
3.4.2.1.3.8	RIU System Timing Source	c) The RIU shall report the status of the Timing Source to the MMC function.	SRD Section: 3.2.6.2
3.4.2.1.3.9	RIU Telecommunications Monitoring	a) The RIU shall inhibit RF transmissions upon detection of the loss of telecommunications service. [SRD 3.2.4.5.2]	SRD Section: 3.2.4.5.2
3.4.2.2	RIU Subsystem Interfaces	a) The RIU shall have the following interfaces: 1. RIU/Analog Radio interface 2. RIU/MDR PCM voice interface 3. RIU/MDR digital voice/data interface 4. RIU/MDT interface 5. RIU/Timing Source interface 6. RIU/Communication Link interface to GNI	RD Section: 5.1.3; SRD Section: 3.2.2; FAA-E-2885
3.4.2.2.1	RIU Analog Radio Voice Interfaces	a) The RIU shall interface with up to four channels of existing analog UHF radio equipment, including Main/Standby Transmitter/Receiver units. [FAA-P-2883; FAA-P-2884]	FAA-P-2883; FAA-P-2884

SRD Section	SRD Title	Requirements	Source Document
3.4.2.2.1	RIU Analog Radio Voice Interfaces	b) The RIU shall use the digital audio signal from the GNI to drive the audio input of the analog voice radios.	SRD Section: 3.2.2.2; 3.2.2.3
3.4.2.2.1	RIU Analog Radio Voice Interfaces	c) The RIU shall provide connections to each of the UHF radio's RMMC ports. [RD 5.1.2]	RD Section: 5.1.2
3.4.2.2.2	RIU/MDR Digital Interfaces	a) An RIU shall support up to two MDR transmitters and two MDR receivers.	SRD Section: 3.2.2
3.4.2.2.3	General Data Interfaces	a) The RIU shall provide at least three RS-232 serial communications interfaces for general data interfaces to external devices. [FAA-E-2885]	FAA-E-2885
3.4.2.2.3	General Data Interfaces	b) These general data streams shall have a lower priority than voice, data, or control information.	FAA -E-2885
3.4.2.3	RIU Human Interfaces	a) The RIU shall include an on/off power switch. [RD 6.1.1; FAA Human Factors Design Guide]	RD Section: 6.1.1 FAA Human Factors Design Guide
3.4.2.3	RIU Human Interfaces	b) The RIU shall include a front panel display for the status of frequency, system configuration, equipment state, and mode of operation of the RIU. [RD 6.1.1; FAA Human Factors Design Guide]	RD Section: 6.1.1 FAA Human Factors Design Guide
3.4.2.4	RIU Site Configuration	a) The RIU shall support a configuration with a common RIU supporting the transmitters and receivers associated with a User Group.	SRD Section: 3.2.2.1
3.4.2.4	RIU Site Configuration	b) To support separated transmitter and receiver sites, the RIU subsystem shall support a split-RIU configuration where RIU devices are located at each of the separated sites.	SRD Section: 3.2.2.1
3.4.2.5	RIU/Telecommunications Interfaces	a) The RIU shall interface with at least a 56 kbps digital service via a DDC interface to access the remote GNI. [SRD 3.2.3.8.1]	SRD Section: 3.2.3.8.1
3.4.2.5	RIU/Telecommunications Interfaces	b) The RIU shall interface with analog 4-wire VG-6 ground telecommunications circuits to access the remote GNI, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.3.8.1]	RD Section 4.10.2; SRD Section: 3.2.3.8.1
3.4.2.5	RIU/Telecommunications Interfaces	c) The RIU shall interface with analog 4-wire VG-8 ground telecommunications circuits to access the remote GNI, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.3.8.1]	RD Section: 4.10.2; SRD Section: 3.2.3.8.1
3.4.2.5	RIU/Telecommunications Interfaces	d) The RIU shall support sufficient telecommunications interfaces to provide dual control over redundant telecommunications links.	RD Section: 10.2.1; 10.2.1.2

SRD Section	SRD Title	Requirements	Source Document
3.4.2.5	RIU/Telecommunications Interfaces	e) When configured for standby telecommunications backup, the RIU shall detect transmission path failures (defined as an inability to communicate with an GNI for a 1 second period), switch to an alternate transmission path, and restore communications to the GNI. [FAA-E-2885, 3.2.2.4]	FAA-E-2885 Section: 3.2.2.4
3.4.2.5	RIU/Telecommunications Interfaces	f) When configured for hot telecommunications backup with a GNI, the RIU shall continue to communicate with the GNI with no loss of data when one of the telecommunications interfaces is degraded or fails. [SRD 3.2.3.8.2.2]	SRD Section: 3.2.3.8.2.2
3.4.2.6	RIU/GNI Interfaces	a) The RIU shall interface with up to two GNIs via RIU/Telecommunications interface(s). [SRD 3.2.3.6.7]	SRD Section: 3.2.3.6.7
3.4.2.6	RIU/GNI Interfaces	b) For dual control the RIU shall interface with two GNIs via RIU/Telecommunications interface(s) and/or direct connectivity. [SRD 3.2.3.6.7]	SRD Section: 3.2.3.6.7
3.4.2.6	RIU/GNI Interfaces	c) The RIU shall provide authentication of the information between the RIU and GNI. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.2.6	RIU/GNI Interfaces	d) The RIU shall provide integrity assurance of the information between the RIU and GNI. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.2.7	Power Interfaces	a) The RIU shall interface with existing power in NAS facilities consistent with FAA Order 6950.2D. [SRD 3.2.2.1, 3.8.2.1]	RD Section: 4.9.1; SRD Section 3.2.2.1; 3.8.2.1
3.4.2.8	Signaling	a) The RIU shall communicate the following signals with the GNI: 1. PTT/PTT Release [SRD 3.2.3.5] 2. Receiver Mute/Unmute [SRD 3.2.20] 3. Voice Preemption [RD3.3.1; SRD 3.2.6] 4. Main/Standby Radio Selection 5. BUEC Select/Reset	SRD Section: 3.2.3.5; 3.2.20; 3.2.6; RD Section: 3.3.1

SRD Section	SRD Title	Requirements	Source Document
3.4.2.8	Signaling	b) The RIU shall provide confirmation signals indicating successful completion of the following actions to the GNI: 1. PTT/PTT Release [SRD 3.2.3.5] 2. Receiver Mute/Unmute [SRD 3.2.20] 3. Squelch Break [SRD 3.2.16] 4. Main/Standby Selection [RD 3.1.1.4] 5. BUEC Select/Reset [RD 3.1.1.4]	SRD Section: 3.2.3.5; 3.2.20; 3.2.6; RD Section: 3.1.1.4
3.4.2.8	Signaling	c) The RIU shall mute the received audio of the UHF and/or VHF radios when so commanded. [SRD 3.2.20]	SRD Section: 3.2.20
3.4.2.8	Signaling	d) The RIU shall indicate 'Channel Busy' back to the control site when a PTT is asserted (without a voice preemption command present) and a VDL Mode 3 voice access has been denied.	RD Section: 3.1.1.4
3.4.2.8	Signaling	e) The RIU shall be configurable to either pass through a PTT /PTT Release Confirmation signal or generate the signal per f). [RD 3.1.7.1; SRD 3.2.3.5]	RD Section 3.17.1; SRD Section: 3.2.3.5
3.4.2.8	Signaling	f) The RIU shall utilize the receiver to loop back the transmitted audio to determine the RIU-generated PTT/PTT Release Confirmation signal. [RD 3.1.7.1; SRD 3.2.3.5]	RD Section: 3.1.7.1; SRD Section: 3.2.3.5
3.4.2.8	Signaling	g) The RIU shall use the End of Message (EOM) bit or lack of voice messages to indicate squelch break inactive, while operating in VDL Mode 3 mode. [SRD 3.2.16]	RD Section: 3.1.1.4; SRD Section: 3.2.16
3.4.2.8	Signaling	h) The RIU shall use signaling information from the GNI to select the active MDR and UHF radio units. [FAA-E-2885; SRD 3.2.15]	FAA-E-2885; SRD Section:3.2.15
3.4.2.8	Signaling	i) When any PTT is activated, the RIU shall inhibit the main/standby (M/S) select function for that frequency (i.e., inhibit the re-routing of the voice and control signals and inhibit the switching of the antenna transfer relay). [SRD 3.2.15.1e]	SRD Section: 3.2.15.1e
3.4.2.8	Signaling	j) When the RIU is operating in Dual Control mode and when another user overrides access at the RIU, the RIU shall pass VHF and UHF Lockout signals back to the GNI to indicate when access to the RIU is lost. [RD 3.1.6.1; SRD3.2.4.2a]	RD Section: 3.1.6.1; SRD Section: 3.2.4.2a
3.4.2.9	RIU Reliability/Maintainability	a) The RIU shall support critical services per NAS-SR-1000.	NAS-SR-1000

SRD Section	SRD Title	Requirements	Source Document
3.4.3.1.1	GNI/VSCE Interfaces	a) The GNI shall interface with existing VSCE (e.g., VSCS, ETVS, ICSS, RDVS, STVS) via existing interfaces (e.g., Single channel (V+U) and quad channel (V/U/M/S)). [FAA-E-2885]	FAA-E-2885
3.4.3.1.1	GNI/VSCE Interfaces	b) The GNI shall interface with voice switches via a common digital interface.	RD Section 3.1.9.1;3.2.14.1; 3.12.15.1
3.4.3.1.2	GNI/Telecommunications Interfaces	a) The GNI shall interface with at least a 56 kbps digital service via a DDC interface to access the remote RIU. [SRD 3.2.3.8.1]	SRD Section: 3.2.3.8.1
3.4.3.1.2	GNI/Telecommunications Interfaces	b) The GNI shall interface with analog 4-wire VG-6 ground telecommunications circuits to access the remote RIU, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.3.8.1]	RD Section: 4.10.2; SRD Section: 3.2.3.8.1
3.4.3.1.2	GNI/Telecommunications Interfaces	c) The GNI shall interface with analog 4-wire VG-8 ground telecommunications circuits to access the remote RIU, when the digital interface is not being used. [RD 4.10.2; SRD 3.2.3.8.1]	RD Section: 4.10.2; SRD Section: 3.2.3.8.1
3.4.3.1.2	GNI/Telecommunications Interfaces	d) The GNI shall support redundant telecommunications interfaces for each RIU per Section 3.2.3.8.1.e).	SRD Section: 3.2.3.8.1e
3.4.3.1.2	GNI/Telecommunications Interfaces	e) When configured for standby telecommunications backup, the GNI shall detect transmission path failures (defined as an inability to communicate with an RIU for a 1 second period), switch to an alternate transmission path, and restore communications to the RIU. [FAA-E-2885, 3.2.2.4]	FAA-E-2885, Section: 3.2.2.4
3.4.3.1.2	GNI/Telecommunications Interfaces	f) When configured for hot telecommunications backup with an RIU, the GNI shall simultaneously communicate over the redundant telecommunications interfaces with that RIU. [SRD 3.2.3.8.2.2]	SRD Section: 3.2.3.8.2
3.4.3.1.2	GNI/Telecommunications Interfaces	g) When configured for hot telecommunications backup with an RIU, the GNI shall be able to use information from either interface without interfering with the operation of the communications system. [SRD 3.2.3.8.2.2]	SRD Section: 3.2.3.8.2
3.4.3.1.2	GNI/Telecommunications Interfaces	h) When configured for standby telecommunications backup with an RIU, the GNI shall communicate over at least one telecommunications interface with that RIU. [FAA-E-2885, 3.2.2.4]	FAA-E-2885 Section: 3.2.2.4
3.4.3.1.3	GNI/RIU Interfaces	a) The GNI shall interface with RIUs via the GNI/Telecommunications interface.	SRD Section: 3.2.3.8.1

SRD Section	SRD Title	Requirements	Source Document
3.4.3.1.3	GNI/RIU Interfaces	b) The GNI shall be scalable in the number of RIUs that may be supported.	RD Section: 3.14.1; 3.15.1
3.4.3.1.3	GNI/RIU Interfaces	c) The GNI shall provide authentication of the information between the GNI and RIU. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.3.1.3	GNI/RIU Interfaces	d) The GNI shall provide integrity assurance of the information between the GNI and RIU. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.3.1.3	GNI/RIU Interfaces	e) The GNI shall support a configuration with separate RIUs for transmitter and receiver.	SRD Section: 3.2.2
3.4.3.1.4	GNI/Router Interfaces	a) A GNI shall interface with an A/G router via a GNI Data Switch function, per Appendix B.4. [RD Att 2]	RD Att 2; SRD Section 3.3.3.2.1.2
3.4.3.1.4	GNI/Router Interfaces	b) A GNI shall interface with at least 2 different A/G routers. [SRD App E; RD Att 2]	SRD App E; RD Att 2
3.4.3.1.5	GNI/GNI Interfaces	a) The GNI Data Switch function shall merge data communication paths from GNIs to an A/G router. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.5	GNI/GNI Interfaces	b) The GNI Data Switch function shall be used to interconnect GNIs. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.5	GNI/GNI Interfaces	c) GNIs from adjacent control facilities shall coordinate handoffs of aircraft between these facilities. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.5	GNI/GNI Interfaces	d) The GNI shall provide authentication of the information between GNIs. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.3.1.5	GNI/GNI Interfaces	e) The GNI shall provide integrity assurance of the information between GNIs. [RD 7.3]	RD Section: 7.2.1; 7.3.1.1
3.4.3.1.5	GNI/GNI Interfaces	f) The GNI shall support at least 2 paths for GNI interconnections. [SRD App E]	SRD App E
3.4.3.1.6	GNI/Automation Interfaces	a) The GNI shall interface with the automation system to receive Next Channel Uplink information. [RD 6.1.2; SRD 3.2.1.3a]	RD Section: 6.1.2; SRD Section: 3.2.1.3a
3.4.3.1.6	GNI/Automation Interfaces	b) The GNI shall receive confirmation from the radio site as to the success of the uplink of the Next Channel Uplink information. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.6	GNI/Automation Interfaces	c) The GNI shall present to the automation system the confirmation signal on success of the Next Channel Uplink transmission. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.6	GNI/Automation Interfaces	d) The GNI shall deliver Next Channel Uplink confirmations to the automation system. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a

SRD Section	SRD Title	Requirements	Source Document
3.4.3.1.6	GNI/Automation Interfaces	e) The GNI shall provide indication to the automation system of the login status of aircraft. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.6	GNI/Automation Interfaces	f) The GNI shall provide indication to the automation system of the Talker ID (Aircraft ICAO Address) of the aircraft communicating on the voice channel for VDL Mode 3. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.6	GNI/Automation Interfaces	g) The GNI shall provide indication to the automation system of received Urgent Downlink Requests for VDL Mode 3. [SRD 3.2.1.3a]	SRD Section: 3.2.1.3a
3.4.3.1.7	GNI General Purpose Interfaces	a) The GNI shall provide at least 3 RS-232 data connections for use in general messaging with the remote site via the RIU.	FAA-E-2885
3.4.3.1.7	GNI General Purpose Interfaces	b) The general data streams shall have a lower priority than voice, data, or control information.	FAA-E-2885
3.4.3.1.8	GNI Man-Machine Interfaces	a) The GNI shall indicate the operational voice activity of each voice circuit.	RD Section 3.1.1.4; SRD Section: 3.2.3.6
3.4.3.1.8	GNI Man-Machine Interfaces	b) The GNI shall indicate the status of each thread.	RD Section: 3.1.1.4;
3.4.3.1.8	GNI Man-Machine Interfaces	c) The GNI shall be configurable only from the NEXCOM/NIMS interface and the MMC Workstation. [SRD 3.4.6]	RD Section 5.1.2; 7.2.1; 7.3.1.1; SRD Section: 3.4.6
3.4.3.1.9	Power Interfaces	a) The GNI shall interface with existing critical power in NAS facilities consistent with FAA Order 6950.2D. [SRD 3.2.2.2, 3.8.2.1]	SRD Section: 3.2.2.2; 3.8.2.1
3.4.3.1.9	Power Interfaces	b) The GNI shall comply with requirements of the critical power bus. [SRD 3.2.2.2]	SRD Section: 3.2.2.2
3.4.3.1.9	Power Interfaces	c) The GNI shall continue to operate up to 4 hours with loss of critical power. [Potential NCPs on RCE]	Potential NCPs on RCE
3.4.3.2.1	Air/Ground Voice and Data	a) The GNI shall multiplex voice and data for transmission to the appropriate ground station RIU.	RD Section: 3.1.9.1; Attachment 2 par.6 Simultaneous Access to Voice and Data Communications
3.4.3.2.2	Signaling	a) The GNI shall pass the signaling indicated in Section 3.4.2.8 b), h) and j) from the VSCE to the RIU: [RD 3.4.1; FAA-E-2885]	RD Section: 2.4.2.8; 10.1.2

SRD Section	SRD Title	Requirements	Source Document
3.4.3.2.2	Signaling	b) The GNI shall return confirmations of successful action completion from the RIU to the VSCE as indicated in Section 3.4.2.8 d). [RD 3.4.1; FAA-E-2885]	RD Section: 3.4.1; FAA-E-2885
3.4.3.2.2	Signaling	c) The GNI shall pass the signaling from the RIU to the VSCE as indicated in Section 3.4.2.8 b), f), j), and l). [FAA-E-2885]	FAA-E-2885
3.4.3.3	GNI Subsystem Voice Operation	a) The GNI shall compress/decompress speech using the vocoder specified in ICAO Annex 10, Vol. III, Part 1, Chapter 6 for each Talk Group. [RD 3.2.6.1, 5.4.1]	RD Section: 3.2.6.1; 5.4.1
3.4.3.4.1	VDL Mode 3 Data Operation	a) The GNI shall provide VDL 8208 Packet Layer Protocol (PLP) compression, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3 and Appendix J. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	b) The GNI shall provide CLNP frame mode compression, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3, and Appendix K. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	c) The GNI shall provide raw subnetwork interface data transfer services for non-ATN messaging, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	d) The GNI shall provide IEC/ISO 8208 data transfer services, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	e) The GNI shall provide CLNP data transfer services, as requested by mobile users, as defined in RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	f) The GNI shall be upgradeable to provide ATN Frame Mode subnetwork interface data transfer services, as requested by mobile users, as defined in Change 1 to RTCA/DO-224A, Section 3.3.3. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	g) The GNI shall provide MbB services as defined in RTCA/DO-224A, Section 3.3.3.3. [RD 5.4.1; SRD 3.2.1.3a]	RD Section: 5.4.1; SRD Section: 3.2.1.3a
3.4.3.4.1	VDL Mode 3 Data Operation	h) The GNI group shall report to the A/G Router only those connectivity changes to the subnetwork that affect A/G Router connectivity decisions, as defined in RTCA DO-224A, Section 3.3.2.3. [SRD 3.2.3.4.3]	RD Section: 5.4.1; SRD Section: 3.2.3.4.3
3.4.3.4.1	VDL Mode 3 Data Operation	i) The GNI shall not permit any of its functions or components to be used to access unauthorized parts of the NAS external to the NEXCOM System. [RD Att 2]	RD Section: 7.2.1; 7.3.1.1; Attachment 2 par.15

SRD Section	SRD Title	Requirements	Source Document
			Information Security
3.4.3.5.1	GNI Subsystem Remote Monitoring Functions	a) The GNI shall monitor the functional status of its associated RIUs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.1	GNI Subsystem Remote Monitoring Functions	b) The GNI shall monitor the functional status of its associated Timing Sources. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.1	GNI Subsystem Remote Monitoring Functions	c) The GNI shall monitor the functional status of its associated MDRs . [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.1	GNI Subsystem Remote Monitoring Functions	d) The GNI shall monitor the functional status of its associated UHF radios. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.1	GNI Subsystem Remote Monitoring Functions	e) The GNI shall support monitoring of the port status of its A/G Router(s). [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.2	GNI Subsystem Remote Control Functions	a) The GNI shall support remote control its associated RIUs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.2	GNI Subsystem Remote Control Functions	b) The GNI shall support remote control its associated MDRs. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.2	GNI Subsystem Remote Control Functions	c) The GNI shall support remote control its associated UHF radios. [RD 3.3.3, 5.1.3; SRD 3.4.6.6]	RD Section: 3.3.3; 5.1.3; SRD Section: 3.4.6.6
3.4.3.5.2	GNI Subsystem Remote Control Functions	d) The GNI shall coordinate operation of primary and backup site radio strings for a given User Group.	FAA-E-2885
3.4.3.5.3	GNI/MMC Workstation Interface	a) Each GNI shall interface to the collocated MMC Workstation.	RD Section: 5.1.3
3.4.3.6	GNI Reliability/Maintainability	a) The GNI shall support critical services per NAS-SR-1000.	NAS-SR-1000
3.4.3.6.1	GNI Redundancy	a) The failure of any thread(s) within the GNI to its RIU shall not degrade communications of any other GNI/RIU threads. [RD 3.2.1.2]	RD Section 3.2.1.2

SRD Section	SRD Title	Requirements	Source Document
3.4.3.6.1	GNI Redundancy	b) A failure within a GNI shall not cause loss of communications within a User Group. [RD 3.2.1.2, Appendix E]	RD Section: 3.2.1.2; App E
3.4.3.6.1	GNI Redundancy	c) Failure of a single GNI thread shall not cause loss of A/G communications Services. [RD 3.2.1.2]	RD Section: 3.2.1.2
3.4.4.1	A/G Routing	a) The A/G Router shall implement air/ground routing protocols as per ICAO Document 9705. [SRD 3.2.17.2]	SRD Section: 3.2.17.2
3.4.4.1	A/G Routing	b) Each A/G router shall be located at an ARTCC. [SRD 3.3.5]	SRD Section: 3.3.5
3.4.4.1	A/G Routing	c) Each A/G router shall be responsible for providing the ATN subnetwork services to the GNI(s) within its domain. [SRD 3.3.5]	SRD Section: 3.3.5
3.4.4.1.1.1	SNDCF for ISO/IEC 8208 Mobile Subnetworks	a) The A/G Router shall implement the SNDCF for ISO/IEC 8208 Mobile Subnetworks as per ICAO Document 9705, as an interface to the VDL Mode 3 8208 PLP Compressor. [SRD 3.2.1.3; ICAO Doc 9705]	SRD Section: 3.2.1.3; ICAO Doc 9705
3.4.4.1.1.2	SNDCF for Frame Mode Mobile Subnetworks	a) The A/G Router shall be upgradeable to implement the SNDCF for Frame Mode Mobile Subnetworks as per ICAO Document 9705, as an interface to the ATN Frame Mode Compressor. [SRD 3.2.1.3; ICAO Doc 9705]	SRD Section: 3.2.1.3; ICAO Doc 9705
3.4.4.1.1.3	SNDCF for VDL Mode 3 Frame Mode Mobile Subnetworks	a) The A/G Router shall implement the SNDCF for VDL Mode 3 Frame Mode Mobile Subnetworks as per ICAO Document 9705, as an interface to CLNP Frame Mode Compressor. [SRD 3.2.1.3; ICAO Doc 9705]	SRD Section: 3.2.1.3; ICAO Doc 9705
3.4.4.2.1	Local MMC	a) The A/G Router shall provide local configuration, monitoring and control for the router. [SRD 3.4.6.1]	SRD Section: 3.4.6.1
3.4.4.2.2	Remote MMC	a) The A/G Router shall provide MMC access of the router to the NIMS. [SRD 3.4.6]	SRD Section: 3.4.6; 5.1.2; 5.1.3
3.4.4.3	A/G Router Reliability/Maintainability	a) The A/G Router subsystem shall provide at least two independent paths from the GNI to the ATN network. [SRD 3.5.3.1, E.5]	SRD Section: 3.5.3.1; E.5
3.4.5	MDT Functional Requirements	a) The MDT shall provide a means for asserting the same operational functions normally available via the VSCE interface (e.g., Main, Standby, and BUEC transmitters and receivers, PTT, Mute, etc.) for each Talk Group(s) to which it is attached.	RD Section: 3.2.5; 8.3.1
3.4.5	MDT Functional Requirements	b) The MDT shall provide a means for monitoring the operational status of the User Group(s) to which it is attached.	RD Section: 3.1.1.4; 5.1.3
3.4.5.1	Local MMC	a) The NEXCOM MDT function shall use an existing NAS MDT to access local maintenance, monitoring and control functions of the RIU, and MDR. [SRD 3.4.6.1]	SRD Section: 3.4.6.1

SRD Section	SRD Title	Requirements	Source Document
3.4.5.2	Remote MMC	a) When connected to an RIU, the NEXCOM MDT function shall access remote MMC information from all MDRs, and UHF radios that are attached to the RIU. [SRD 3.4.6]	SRD Section: 3.4.6
3.4.5.3	Logging	a) The MDT shall download and store the log files from the RIUs, and MDRs at a site. [SRD 3.4.1.4]	SRD Section: 3.4.1.4
3.4.6	Workstation Functional Requirements	a) The MMCWS shall provide a means for asserting the same operational functions normally available via the VSCE interface (e.g., Main, Standby, and BUEC transmitters and receivers, PTT, Mute, etc.) for each Talk Group(s) to which it is attached.	RD Section: 3.2.5; 8.3.1
3.4.6	Workstation Functional Requirements	b) The MMCWS shall provide a means for monitoring the operational status of the User Group(s) to which it is attached.	RD Section: 3.1.1.4; 5.1.3
3.4.6.1	Local MMC	a) The MMCWS shall be a control access point for local maintenance, monitoring and control functions of the GNI. [SRD 3.4.6.1]	SRD Section: 3.4.6.1
3.4.6.2	Remote MMC	a) The MMCWS shall access remote MMC information from all connected RIUs. [SRD 3.4.6.2]	SRD Section: 3.4.6.2
3.4.6.2	Remote MMC	b) The MMCWS shall access remote MMC information from all connected MDRs. [SRD 3.4.6.2]	SRD Section: 3.4.6.2
3.4.6.2	Remote MMC	c) The MMCWS shall access remote MMC information from all connected UHF radios. [SRD 3.4.6.2]	SRD Section: 3.4.6.2
3.4.6.2	Remote MMC	d) The MMCWS shall access remote MMC information from all connected A/G Routers. [SRD 3.4.6.2]	SRD Section: 3.4.6.2
3.4.6.2	Remote MMC	e) The MMCWS shall monitor MMC information from the Data Link Application End System responsible for the GNI with which the MMCWS is associated. [SRD 3.4.6.2]	SRD Section: 3.4.6.2
3.4.6.3	Logging	a) The MMCWS shall log all alerts and alarms from all NEXCOM Subsystems. [SRD 3.4.1.4]	SRD Section: 3.4.1.4
3.4.6.3	Logging	b) The MMCWS shall log all MMC control commands sent to the NEXCOM Subsystems, except the A/G Router. [SRD 3.4.1.4]	SRD Section: 3.4.1.4
3.4.6.3	Logging	c) The MMCWS shall log all access attempts to the MMC system. [SRD 3.4.1.4]	SRD Section: 3.4.1.4
3.4.6.4	Platform Requirements	a) The MMCWS shall reside on platforms compatible with those already in the NAS, to include MDT platforms.	RD Section: 10.2.1.4
3.4.7.1	Time Conditioning	a) The Timing Source shall synchronize timing with the Timing Reference.	SRD Section: 3.2.6.1

SRD Section	SRD Title	Requirements	Source Document
3.4.7.1	Time Conditioning	b) The Timing Source shall provide timing to connected RIU (s).	SRD Section: 3.4.2.1.3.8
3.4.7.2	Timing Source Interfaces	a) The Timing Source shall interface with the Timing Reference.	SRD Section: 3.
3.4.7.2	Timing Source Interfaces	b) The Timing Source shall interface to collocated RIU (s) [SRD 3.2.6.3.a]	SRD Section: 3.2.6.3.a
3.4.7.3	Status Monitoring	a) The Timing Source shall monitor the status of the Timing Reference.	SRD Section: 3.2.6.1; 3.2.6.2
3.4.7.3	Status Monitoring	b) The Timing Source shall provide status information concerning the Timing Reference to the RIU.	RD Section: 5.1.3
3.5.1.1	MDR Sustainment Operation	a) The NEXCOM MDR subsystems shall meet the performance requirements specified in the following: 1. FAA-P-2883, Purchase Description, VHF/UHF Air/Ground Communications Receiver 2. FAA-P-2884, Purchase Description, VHF/UHF Air/Ground Communications Transmitter	FAA-P-2883; FAA-P-2884
3.5.1.2.2	Uplink Digital Voice Delay in MDR Transmitter	a) The uplink audio processing delay contribution of each MDR transmitter in digital voice modes shall be less than or equal to 6 ms, measured from the reception of the complete High-Level Data Link Control (HDLC) voice burst message containing vocoder frame 6 from the RIU to the time when the MDR begins RF transmission (referenced to the antenna port) of the first D8PSK symbol in vocoder frame 6. [SRD 3.3.4.2.1]	SRD Section: 3.3.4.2.1
3.5.1.2.3	Uplink Analog Voice Delay in MDR Transmitter	a) The uplink audio processing delay contribution of each MDR transmitter in analog voice modes via the PCM voice interface to the RIU shall be less than or equal to 9 ms, measured from the reception of the second complete RIU HDLC PCM voice message to the time when the MDR begins RF transmission (referenced to the antenna port) of the first PCM voice message. [SRD 3.3.4.2.1]	SRD Section: 3.3.4.2.1
3.5.1.2.3	Uplink Analog Voice Delay in MDR Transmitter	b) In sustainment mode, the audio processing delay in the MDR transmitter, measured from the analog voice input port on the MDR transmitter to the transmitter antenna port, with the Push-to-Talk (PTT) signal line activated at the RCE/MDR interface, shall be less than 13 ms. [SRD 3.3.4.2.1]	SRD Section: 3.3.4.2.1

SRD Section	SRD Title	Requirements	Source Document
3.5.1.2.4	Downlink Digital Voice Delay in MDR Receiver	a) The downlink audio processing delay contribution of the MDR receiver in digital voice modes shall be less than or equal to 17 ms, measured from the Time of Arrival of the last D8PSK symbol of the first vocoder frame in a VDL Mode 3 voice burst at the antenna port to the time when the MDR completes transmission of the HDLC voice burst message containing vocoder frame 1 to the RIU. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.1.2.5	Downlink Analog Voice Delay in MDR Receiver	a) The downlink audio processing delay contribution of the MDR receiver in analog voice modes via the PCM voice interface to the RIU shall be less than or equal to 83 ms, measured from MDR receiver squelch break to the time when the MDR receiver completes transmission of the second HDLC PCM voice message to the RIU. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.1.2.5	Downlink Analog Voice Delay in MDR Receiver	b) In sustainment mode, the audio processing delay in the MDR receiver, measured from the RF signal received at the MDR receiver antenna port to the corresponding demodulated analog voice output of the receiver, shall be less than 13 milliseconds. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.1.5	MDR System Timing	a) The time offsets for transmission arrival for VDL Mode 3 voice, data or management burst messages shall not deviate by more than ±10 microseconds from the MDR's timing reference point.	SRD Section: 3.3.2.1
3.5.1.5	MDR System Timing	b) The time offsets for the reception window for VDL Mode 3 voice, data or management burst messages shall be accurate to ±10 microseconds.	SRD Section: 3.3.2.1
3.5.1.6	MDR Reliability/Maintainability	a) The MDR MTBF shall be equal to or greater than 26,280 operational hours. [SRD 3.5.3.1]	RD Section: 3.2.2.1; SRD Section 3.5.3.1
3.5.2.1.3.1.1	Uplink Digital Voice Delay in RIU/Vocoding in GNI	a) In digital voice modes when vocoding in the GNI, the uplink audio processing delay contribution of the RIU shall be less than or equal to : Where, N is the number of vocoder frames in the voice burst message (1 to 4) from the GNI, and measured from reception of the HDLC voice burst message from the GNI to the time when the RIU completes relay transmission of the same HDLC voice burst message to the MDR. [SRD 3.3.4.2.1] Note: This incurs a maximum allowable delay of 8.35.ms for N=4.	SRD Section: 3.3.4.2.1

SRD Section	SRD Title	Requirements	Source Document
3.5.2.1.3.1.2	Uplink Analog Voice Delay in RIU	a) The uplink audio processing delay contribution of the RIU in analog voice modes with GNI vocoding shall be less than or equal to 75 ms, measured from the arrival of voice bursts from the GNI to the time when the RIU completes transmission of the second HDLC PCM voice burst message of the voice transmission to the MDR. [SRD 3.3.4.2.1]	SRD Section: 3.3.4.2.1
3.5.2.1.3.1.2	Uplink Analog Voice Delay in RIU	b) The uplink audio processing delay contribution of the RIU in analog voice modes with GNI vocoding shall be less than or equal to 30 ms, measured from the arrival of voice bursts from the GNI to the time when the audio is available at the RIU/Analog Radio interface. [SRD 3.3.4.2.1]	SRD Section: 3.3.4.2.1
3.5.2.1.3.1.3	Downlink Digital Voice Delay in RIU/Vocoding in GNI	a) In digital voice modes when vocoding within the GNI, the downlink audio processing delay contribution of the RIU shall be less than or equal to: Where, N is the number of vocoder frames in the voice burst message received from the MDR, and measured time from reception of the MDR HDLC voice burst message to the time when the RIU completes relay transmission of the same HDLC voice burst message to the GNI. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.2.1.3.1.4	Downlink Analog Voice Delay in RIU	a) The downlink audio processing delay contribution of the RIU in analog voice modes via the PCM voice interface from the MDR shall be less than or equal to 87 ms, measured from the reception of the second complete MDR HDLC PCM voice message in an analog voice reception to the time when the RIU begins sending vocoded data to the GNI. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.2.1.3.1.4	Downlink Analog Voice Delay in RIU	b) The downlink audio processing delay contribution of the RIU in analog voice modes via the analog radio interface shall be less than or equal to 87 ms, measured from the presence of audio at the RIU/Analog Radio interface to the time when the RIU begins sending vocoded data to the GNI. [SRD 3.3.4.2.2]	SRD Section: 3.3.4.2.2
3.5.2.1.4.1	RIU/GNI Message Delays	a) The RIU shall complete the transmission of a valid DLS frame over the RIU/GNI telecommunications link no later than 500 ms after the last data burst message associated with the DLS frame is received from the MDR Receiver.	SRD Section: 3.2.2.1
3.5.2.1.4.1	RIU/GNI Message Delays	b) The RIU shall provide timing signals to the GNI to minimize end-end voice delay.	SRD Section: 3.4.2.1.4.1
3.5.2.1.8	System Timing	a) The internal RIU 6-second epoch timing reference shall be locked to the Timing Source within a tolerance of ±10 microseconds. [SRD 3.2.14.3]	SRD Section: 3.2.14.3

SRD Section	SRD Title	Requirements	Source Document
3.5.2.2.4	General Data Interfaces	a) The RIU shall interface at up to 9,600 bps communications on each of the general data interfaces. [FAA-E-2885]	FAA-E-2885
3.5.2.2.4	General Data Interfaces	b) The RIU shall provide an aggregate rate of at least 1,200 bps for all of the general data interfaces.	SRD Section: 3.4.2.2.4
3.5.2.4	RIU Site Configuration	a) The RIU shall be located within 6,000 feet of the MDR transmitter to ensure proper timing of the MDR transmissions.	SRD Section: 3.4.2.4
3.5.2.5.1	Transmission Path Failure Restoration	a) For transmission path failures where a redundant path exists, the RIU shall restore communications to the GNI via the alternate path within 3 seconds. [FAA-E-2885]	3.5.2.5.1
3.5.2.5.1	Transmission Path Failure Restoration	b) For communications loss less than 3 seconds in duration, the RIU shall restore communications to the GNI within {120} milliseconds.	SRD Section: 3.4.2.5.1
3.5.2.5.1	Transmission Path Failure Restoration	c) Given a new telecommunications path, the RIU shall establish the connection for operational use within 3 seconds.	SRD Section: 3.4.2.5.1
3.5.2.5.1	Transmission Path Failure Restoration	d) The RIU shall complete the switch back to the primary telecommunications link within {TBD} ms after receiving the GNI switching command without loss of data.	SRD Section: 3.4.2.5.1
3.5.2.8.1	RIU Signaling Integrity	a) The RIU shall ensure that no more than one control signal in one million is falsely interpreted or not completed. [FAA-E-2885, 3.2.3.2.1]	RD Section: 3.5.3.2.2.2.3
3.5.2.9	RIU Reliability/Maintainability	a) The RIU MTBF shall be equal to or greater than 40,000 operational hours. [RD 3.2.2; SRD 3.5.3.1, E.6]	RD Section: 3.5.3.2.2.2.3; SRD Section: 3.5.3.1 ; E.6
3.5.3.1.2.1	Transmission Path Failure Restoration	a) For transmission path failures where a redundant path exists and configured for standby telecommunications backup, the GNI shall restore communications to the RIU via the alternate path within 1 second. [SRD 3.3.3.8.2.1; FAA-E-2885, 3.2.2.4]	RD Section: 3.5.3.2.2.2.11; SRD Section: 3.3.3.8.2.1; FAA-E-2885 Section: 3.2.2.4
3.5.3.1.2.1	Transmission Path Failure Restoration	b) For communications loss less than 1 second in duration, the GNI shall restore communications to the RIU within 120 milliseconds. [SRD 3.3.3.8.2 b]	RD Section: 3.5.3.4.1; SRD Section: 3.3.3.8.2
3.5.3.1.2.1	Transmission Path Failure Restoration	c) Given a new telecommunications path, the GNI shall establish the connection for operational use within 3 seconds. [SRD 3.2.19.X]	RD Section: 3.5.3.4.1
3.5.3.1.2.1	Transmission Path Failure Restoration	d) The GNI shall complete the switch back to the primary telecommunications link in less than 3 seconds after the primary link is restored, with no loss of data when PTT is deactivated.	SRD Section: 3.4.3.1.2.1

SRD Section	SRD Title	Requirements	Source Document
3.5.3.1.3	GNI/RIU Interface	a) The GNI shall support a control facility that interfaces to at least {350} RIUs. [SRD 3.3.4.4]	RD Section: 3.5.3.1..8
3.5.3.1..8	General Data Interface	a) The GNI shall interface at up to 9,600 bps communications on each of the general data interfaces of Section 3.4.3.1.8. [FAA-E-2885]	RD Section: 3.5.2.5.1
3.5.3.1..8	General Data Interface	b) The GNI shall provide an aggregate data rate of at least 1200 bps for all of the general data lines.	SRD Section: 3.4.3.1..8
3.5.3.2.2.1	GNI Signaling Integrity	a) The GNI shall ensure that no more than one control signal in one million is falsely interpreted or not completed. [FAA-E-2885, 3.2.3.2.1]	SRD Section: 3.4.3.2.2.1; 3.5.3.1.2.1
3.5.3.2.2.2.1	Radio PTT/PTT Release	a) The response time from the instant the control site subsystem receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes the PTT signal at the RIU/Analog Radio interface shall not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]	SRD Section: 3.4.3.2.2.2.1; 3.5.3.1..8
3.5.3.2.2.2.1	Radio PTT/PTT Release	b) The response time from the instant the control site subsystem receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes PCM voice packets at the RIU/MDR interface shall not exceed 143 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]	SRD Section: 3.4.3.2.2.2.1; 3.5.3.2.2.2.3
3.5.3.2.2.2.1	Radio PTT/PTT Release	c) The response time from the instant the GNI receives a PTT/PTT Release signal from the VSCE, to the instant the RIU provides/removes VDL Mode 3 voice packets at the RIU/MDR interface shall not exceed 165 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1]	SRD Section: 3.4.3.2.2.2.1; 3.5.3.2.2.2.3
3.5.3.2.2.2.2	Radio PTT/PTT Release Confirmation	a) The response time from the instant the RIU provides/removes the keying signal at the RIU/Analog Radio interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]	SRD Section: 3.4.3.2.2.2.2; 3.5.3.2.2.2.11
3.5.3.2.2.2.2	Radio PTT/PTT Release Confirmation	b) The response time from the instant the RIU provides/removes the PCM voice bursts at the RIU/MDR interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]	SRD Section: 3.4.3.2.2.2.2; 3.5.3.4.1

SRD Section	SRD Title	Requirements	Source Document
3.5.3.2.2.2.2	Radio PTT/PTT Release Confirmation	c) The response time from the instant the RIU provides/removes the VDL Mode 3 voice bursts at the RIU/MDR interface, to the instant that the control facility subsystem provides a PTT/PTT Release Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.1.1]	SRD Section: 3.4.3.2.2.2.2; 3.5.3.4.1
3.5.3.2.2.2.3	Radio Squelch Break/Squelch Break Release	a) The response time from the instant the Analog Radio provides/removes the squelch break/squelch break release signal at the RIU/Analog Radio interface, to the instant that the squelch break/squelch break release signal appears at the NEXCOM/VSCE interface shall not exceed 200 ms for 99.9% of the events.	SRD Section: 3.4.3.2.2.2.3
3.5.3.2.2.2.3	Radio Squelch Break/Squelch Break Release	b) The response time from the instant the MDR provides/removes voice bursts at the RIU/MDR interface, to the instant that the control site subsystem provides a squelch break/squelch break release indication at the NEXCOM/VSCE interface shall not exceed 100 ms for 99.9% of the events.	SRD Section: 3.4.3.2.2.2.3
3.5.3.2.2.2.4	Main/Standby Select/Deselect	a) The response time from the instant the VSCE provides the M/S Select/Deselect signal at the NEXCOM/VSCE interface, to the instant the remote site RIU executes both of the following actions shall not exceed 100 ms for 99.9% of the events: [FAA-E-2885, 3.2.3.2.2.2] 1. Switches to the selected main or standby transmitter/receiver, that is, routes the voice and control signals only to/from the selected transmitter/receiver 2. Provides the necessary signaling to the antenna transfer relay via the remote site RIU/Radio interface	FAA-E-2885 Section: 3.2.3.2.2.2
3.5.3.2.2.2.5	Main/Standby Select/Deselect Confirmation	a) The response time from the instant the RIU completes all M/S Select/Deselect actions (i.e., (1) and (2) of {3.5.3.7.4a}), to the instant the control site subsystem provides a M/S Select/Deselect Confirmation signal at the NEXCOM/VSCE interface shall not exceed 250 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.2.1]	FAA-E-2885 Section: 3.2.3.2.2.2.1
3.5.3.2.2.2.6	Receiver Mute/Unmute	a) When configured for RIU Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the receive voice signal is muted/unmuted within the RIU shall not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]	FAA-E-2885 Section: 3.2.3.2.2.3

SRD Section	SRD Title	Requirements	Source Document
3.5.3.2.2.2.6	Receiver Mute/Unmute	b) When configured for Radio Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the signal is available at the RIU/Analog Radio interface shall not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]	FAA-E-2885 Section: 3.2.3.2.2.3
3.5.3.2.2.2.6	Receiver Mute/Unmute	c) When configured for Radio Muting, the response time from the instant the NEXCOM/VSCE interface receives the Receiver Muting/Unmuting signal to the instant the signal is available at the RIU/MDR interface shall not exceed 100 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3]	FAA-E-2885 Section: 3.2.3.2.2.3
3.5.3.2.2.2.7	Receiver Mute/Unmute Confirmation	a) The response time from the instant the voice signal is muted/unmuted in the RIU to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]	FAA-E-2885 Section: 3.2.3.2.2.3.1
3.5.3.2.2.2.7	Receiver Mute/Unmute Confirmation	b) The response time from the instant the Receiver Mute/Unmute Confirmation signal is available at the RIU/Analog Radio interface to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]	FAA-E-2885 Section: 3.2.3.2.2.3.1
3.5.3.2.2.2.7	Receiver Mute/Unmute Confirmation	c) The response time from the instant the Receiver Mute/Unmute Confirmation signal is available at the RIU/MDR interface to the instant the control site subsystem provides the Receiver Mute/Unmute Confirmation signal at the NEXCOM/VSCE interface shall not exceed 340 ms for 99.9% of the events. [FAA-E-2885, 3.2.3.2.2.3.1]	FAA-E-2885 Section: 3.2.3.2.2.3.1
3.5.3.2.2.2.8	VDL Mode 3 Voice Preemption/Preemption Release	a) The voice preemption signal shall be contained in the next scheduled uplink Beacon that occurs at least 50 ms after the reception of the voice preemption and PTT signals from the NEXCOM/VSCE interface for 99.9% of the preemption events. [RD 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1, 4.6]	RD Section: 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1; 4.6
3.5.3.2.2.2.9	VDL Mode 3 Voice Preemption/Preemption Release Confirmation	a) The response time from the instant the VDL Mode 3 voice preemption /preemption release confirmation signal is generated at the RIU to the instant when the voice preemption/preemption release confirmation signal is received at the NEXCOM/VSCE interface shall not exceed 340ms for 99.9% of the events. [RD 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1, 4.6]	RD Section: 3.3.1; ICAO Doc X (Manual for the Implementation of VDL Mode 3) 3.3.1; 4.6

SRD Section	SRD Title	Requirements	Source Document
3.5.3.2.2.2.10	VHF/UHF Lockout/Lockout Release	a) The response time from the instant the VHF/UHF lockout/lockout release condition is declared in the RIU to the instant when the control site subsystem is notified of the VHF/UHF Lockout/lockout release condition shall not exceed 120ms for 99.9% of the events. [RD 3.1.6.1; SRD 3.2.4.2a]	RD Section: 3.1.6.1; SRD Section: 3.2.4.2a
3.5.3.2.2.2.11	VDL Mode 3 Channel Busy	a) The response time from the instant the PTT is received by the RIU to the instant when the Channel Busy signal is received at the NEXCOM/VSCE interface shall not exceed 120ms for 99.9% of the events.	SRD Section: 3.4.3.2.2.2.11
3.5.3.3.1.1	Uplink Digital Voice Delay in GNI	a) The uplink audio processing delay contribution of a GNI subsystem when vocoding shall be less than or equal to 72ms + (5-Nsil)*20ms in digital voice modes, where Nsil is the number of vocoder silence frames transmitted in vocoder frames 1-5 (0 £ Nsil £ 5), and measured from VSCE Push-to-talk activation to the time when the GNI completes transmission of the HDLC voice burst message containing vocoder frame 6 of the first VDL Mode 3 voice burst transmitted to the RIU. [RD 3.2.7.1; SRD 3.3.4.2.1]	RD Section: 3.2.7.1; SRD Section: 3.3.4.2.1
3.5.3.3.1.1.1	Downlink Digital Voice Delay in GNI	a) The downlink audio processing delay contribution of a GNI subsystem when vocoding shall be less than or equal to 61 ms, measured as the time difference between the time specified in the Time of Arrival (TOA) field of the HDLC voice burst message from the RIU/MDR and the time when the GNI begins audio output of the first vocoder frame in the same voice burst message. [RD 3.2.7.1; SRD 3.3.4.2.2]	RD Section: 3.2.7.1; SRD Section: 3.3.4.2.2
3.5.3.4.1	GNI Data Processing Delay	a) The processing delay for multiplexing VDL Mode 3 voice and data of a GNI subsystem shall be less than 10 ms.	SRD Section: 3.4.3.4.1
3.5.3.4.1	GNI Data Processing Delay	b) MMC data processing shall not delay uplink or downlink voice and control data processing or distribution.	SRD Section: 3.4.3.4.1
3.5.3.4.2	GNI Connectivity Report Time	a) The GNI shall comply with connectivity reporting time requirements of ATSC Class B of Section 3.3.3.2.1.4 [SRD 3.3.3.2.1.4]	SRD Section: 3.3.3.2.1.4
3.5.3.6	GNI Reliability/Maintainability	a) The GNI MTBF shall be equal to or greater than 30,000 operational hours. [RD 3.2.1.2, 3.2.2; SRD 3.5.3.1, E.6, E.7]	RD Section: 3.2.1.2; 3.2.2; SRD 3.5.3.1; E.6; E.7
3.5.4.1.1	A/G Router Capacity	a) Each A/G Router shall be capable of supporting up to 1000 aircraft. [SRD 3.2.17.6, 3.3.5.4]	SRD Section: 3.2.17.6; 3.3.5.4
3.5.4.1.2	A/G Router Traffic Loading	a) The A/G Router shall process {1500} join events per hour.[SRD 3.2.17.4, 3.3.5.4]	SRD Section: 3.2.17.4; 3.3.5.4

SRD Section	SRD Title	Requirements	Source Document
3.5.4.1.2	A/G Router Traffic Loading	b) The A/G Router shall process {1500} leave events per hour. [SRD 3.2.17.4, 3.3.5.2]	SRD Section: 3.2.17.4; 3.3.5.2
3.5.4.1.2	A/G Router Traffic Loading	c) The A/G Router shall process {55} Network Protocol Data Units (NPDU) per second, each of 256 octets in length. [SRD 3.3.5.4]	SRD Section: 3.3.5.4
3.5.4.3	A/G Router Reliability/Maintainability	a) The A/G Router MTBF shall be equal to or greater than 19,996 operational hours. [SRD 3.5.3.1, E.5]	SRD Section: 3.5.3.1; E.5
3.5.7.1	Time Conditioning	a) The Timing Source shall maintain system timing within ± 3 microseconds (ms) of the Timing Reference. [SRD 3.3.6.1.1.d]	SRD Section: 3.3.6.1.1.d
3.5.7.2	Time Drift	a) With the loss of the external Timing Reference conditioning, the Timing Source shall maintain system timing for at least 30 days without degrading system operation due to timing. [SRD 3.3.6.2.a]	SRD Section: 3.3.6.2.a
3.5.7.3	Time Standard	a) The Timing Source shall be aligned with UTC on 6 January 1980. [SRD 3.3.6.3.a]	SRD Section: 3.3.6.3.a
3.6.1.2.1	Preemption of Aircraft Voice Transmissions (Controller Override)	a) The VSCE controller interface shall generate a voice preemption signal, when in presence of a PTT, serves to terminate all PTT voice transmission within a Talk Group [RD 3.3.1, 3.3.2; RTCA/DO-224A section 3.3.2.1.1].	RD Section: 3.3.1; 3.3.2; RTCA/DO-224A section 3.3.2.1.1
3.6.1.2.1	Preemption of Aircraft Voice Transmissions (Controller Override)	b) The VSCE shall deliver the preemption signal to the NEXCOM System interface.	SRD Section: 3.2.3.6.2
3.6.1.2.2	Radio Resource Selection Confirmation	a) The VSCE shall indicate to each controller the actual configuration of the equipment supporting that controller's Talk Group based on feedback from the NEXCOM System [RD 3.1.1.4].	RD Section: 3.1.1.4; SRD Section: 3.6.2.1
3.6.1.2.3	Channel Busy Signal	a) The VSCE shall provide an indication to the controller that the requested channel is occupied [SRD 3.2.4; RTCA/DO-224a, 3.3.5.4.3].	RD Section: 3.1.1.4; SRD Section: 3.6.2.2
3.6.1.2.4	Status of Transmissions (RF Activity)	a) The VSCE shall continually indicate to the controller transmit channel status via PTT confirmation [RD 3.1.7.1].	RD Section: 3.1.1.4; 3.1.7.1
3.6.1.2.4	Status of Transmissions (RF Activity)	b) The VSCE shall continually indicate to the controller receive channel status via squelch break [RD 3.1.7.1].	RD Section: 3.1.1.4; 3.1.7.1
3.6.1.2.5	Channel Labeling	a) The VSCE A/G channel selector shall display six numerical characters in accordance with ICAO Annex 10, Vol. V, Ch. 4 [ICAO Annex 10, Vol. V, Ch. 4].	ICAO Annex 10, Vol. V, Ch. 4

SRD Section	SRD Title	Requirements	Source Document
3.6.2.1	Support for Voice, Data and Signaling	a) Telecommunications links shall support voice, data and signaling for the NEXCOM System.	SRD Section: 3.2.3.8.1
3.6.2.2	Telecommunications Interfaces	a) Telecommunications circuits shall interface via either 4-wire or DDC, as needed.	SRD Section: 3.2.3.8.1
3.6.2.3	Physical Path Diversity	a) An RCAG site shall be connected to its control site via two physically diverse paths with no single point of failure.	RD Section: 10.2.1; 10.2.1.2
3.6.2.4	Telecommunications Availability	a) Telecommunications shall support A/G voice and data service.	SRD Section: 3.2.3.8.1
3.6.3	NAS Infrastructure Management System (NIMS) Functional Requirements	a) The NIMS shall interface with the NEXCOM System via an interface compliant with FAA-E-2911 and the NEXCOM/NIMS Interface Control Document (ICD), NAS-IC-TBD.	RD Section: 5.1.2; 5.1.3
3.6.3	NAS Infrastructure Management System (NIMS) Functional Requirements	b) The NIMS shall provide a Computer Human Interface (CHI) for the Remote Maintenance Monitor functions of the NEXCOM System.	RD Section: 5.1.2
3.6.3	NAS Infrastructure Management System (NIMS) Functional Requirements	c) The NIMS shall allow dial-up connection from a NEXCOM MDT to access the NEXCOM MMC.	RD Section: 5.1.2; 5.1.3
3.6.3.1	NIMS/NEXCOM Interface	a) The NIMS interface to the NEXCOM System shall be located at the control site.	RD Section: 5.1.2; 5.1.3
3.6.3.1.1	Status Monitoring	a) The NIMS shall provide status monitoring of the NEXCOM (sub)system(s).	RD Section: 5.1.2; 5.1.3
3.6.3.1.2	Control	a) The NIMS shall control the NEXCOM (sub)system(s).	RD Section: 5.1.2; 5.1.3
3.6.3.1.3	Performance Monitoring	a) The NIMS shall provide performance monitoring of the NEXCOM (sub)system(s).	RD Section: 13.2
3.6.3.1.4	Fault Isolation	a) The NIMS shall access the fault isolation data capabilities of the NEXCOM (sub)system(s).	RD Section: 5.1.2; 5.1.3
3.6.3.1.5	Service/Equipment Certification	a) The NIMS shall provide access to those functions that are provided by the NEXCOM System for Service/Equipment Certification.	RD Section: 5.1.2; 5.1.3
3.6.3.1.6	Digital Link Integrity	a) The NIMS shall provide monitoring status of the Digital Link Integrity provided by the NEXCOM System.	RD Section: 5.1.2; 5.1.3

SRD Section	SRD Title	Requirements	Source Document
3.6.3.1.7	UHF Interface	a) The NEXCOM System shall collect, transport, and provide to the NIMS interface the RMM functionality of the UHF radios co-located with NEXCOM MDRs in accordance with the NEXCOM/NIMS ICD UHF radio subsections.	RD Section: 5.1.2; 5.1.3
3.6.4.2.1	Next Channel Uplink Information	a) The CPDLC shall have the capability to provide the next radio channel setting information to the NEXCOM System. [RD, Attachment 2, Automatic Transfer of Communication]	RD Section: 3.1.9.1; Attachment 2 par. 3 Data Communications Service
3.6.4.2.2	Urgent Downlink Request	a) The automation system shall receive urgent downlink requests from the NEXCOM System and display to the controller. [RD Attachment 2, Queuing of Urgency Calls].	RD Section: 3.1.1.4; 3.1.9.1; Attachment 2 par. 8 Automatic Failure Detection and Fault Isolation
3.6.4.2.3	Aircraft Logged In Feature	a) The automation system shall provide the capability of displaying to the operator all logged in members of a Talk Group based on input from the NEXCOM System.	SRD Section: 3.2.2; RTCA DO-224A
3.6.4.2.4	Talker ID Feature	a) The automation system shall indicate which aircraft is talking on the voice channel to the controller display based on input from the NEXCOM System.	SRD Section: 3.2.2; RTCA DO-224A
3.6.4.2.5	Data Interface	a) The CPDLC automation system shall interface the NEXCOM A/G Router to the ATN network.	SRD Section: 3.2.3.2.1.1; 3.3.3.2.1.1; 3.3.3.2.1.2; 3.4.3.1.4; 3.4.4.1; Appendix B.4
3.7.1.1	Preemption of Aircraft Voice Transmissions Performance	a) The VSCE shall deliver the preemption signal within 50 ms of activation by user for 99.9% of the events.	SRD Section: 3.6.1.1
3.7.1.1	Preemption of Aircraft Voice Transmissions Performance	b) The VSCE shall indicate, to the controller, confirmation of voice preemption activation within 200 ms of receipt a confirmation signal from the NEXCOM System for 99.9% of the events.	SRD Section: 3.6.1.1
3.7.1.2	Radio Resource Selection Confirmation Performance	a) The VSCE latency for the radio resource selection confirmation signal (e.g., Main/Standby Select/Deselect Confirmation or BUEC Select/Reset Confirmation) shall be at most 150 ms for 99.9% of the radio resource selection events.	SRD Section: 3.6.1.2
3.7.1.3	Channel Busy Signal Performance	a) The VSCE latency for the channel busy indicator shall be at most 150 ms for 99.9% of the channel busy events.	SRD Section: 3.6.1.3

SRD Section	SRD Title	Requirements	Source Document
3.7.1.4	Performance of Status of Transmissions	a) The VSCE latency for the controller PTT/PTT Release Confirmation indication shall be at most 200 ms for 99.9% of the PTT confirmation events.	SRD Section: 3.6.1.4
3.7.1.4	Performance of Status of Transmissions	b) The VSCE latency for the squelch break indication shall be at most 150 ms for 99.9% of the squelch break indication events.	SRD Section: 3.6.1.4
3.7.2.1.1	Telecommunications Latency	a) One-way transfer delay contribution from terrestrial Telecommunications alone shall not exceed 25 ms. [RD 3.2.7.1]	RD Section: 3.2.7.1
3.7.2.1.2	Line Characteristics	a) Analog telecommunications shall meet the performance requirements as specified in Bellcore TR-NWT-000335 Voice Grade Special Access Service Transmission Parameter Limits and Interface Combinations, May 1993.	RD Section 4.10
3.7.2.1.2	Line Characteristics	b) Digital telecommunications shall meet the performance requirements as specified in Bellcore GR-499-CORE Transport Systems Generic Requirements (TSGR) Common Requirements, December 1998.	RD Section 4.10
3.7.2.1.2	Line Characteristics	c) Digital telecommunications connectivity shall provide a minimum of 99.9 percent error-free seconds for any 24-hour period.	RD Section 4.10
3.7.2.4	Telecommunications Availability	a) Telecommunications paths shall provide an availability of at least 0.998.	RD Section: 4.10; SRD App E
3.7.3	NIMS Performance Requirements	a) The NIMS shall provide NEXCOM System RMM performance characteristics in accordance with FAA-E-2911, 3.2.3 a).	RD Section: 5.1.2; 13.2; FAA-E-2911 Section: 3.2.3 a)
3.7.3	NIMS Performance Requirements	b) The NIMS shall not interfere with the operational performance of the NEXCOM System.	RD Section: 5.1.2; 13.2; FAA-E-2911 Section: 3.2.3 a)
3.7.3	NIMS Performance Requirements	c) The NIMS shall accommodate low data (high latency) rates.	RD Section: 5.1.2; 13.2; FAA-E-2911 Section: 3.2.3 a)

APPENDIX E NEXCOM Reliability, Maintainability, and Availability (RMA) Analysis

E.1 Introduction

This appendix provides the reliability/maintainability/availability (RMA) analysis for the NEXCOM System Voice and Data services in the En Route and Terminal domains. The purpose of this appendix is to determine the redundancy and MTBF requirements for the NEXCOM GNI and RIU and to ensure that:

- the RCAG mean time between outages (MTBO) is greater than or equal to 19,996 hours as specified in the NEXCOM Segment 1 RD section 3.2.2.2 in accordance with NAS-SS-1000, Volume I, par. 3.2.2.1.
- the voice service availability (as defined by FAA Order 6040.15, par. 702c) is 0.99999 or greater as specified in the NEXCOM SRD, section 3.3.7.3.1, and the NEXCOM RD, section 3.2.4.1, in accordance with NAS-SS-1000, par. 3.2.1.2.8.2a.
- the data service availability (as defined by FAA Order 6040.15C, par. 702c) is 0.99999 or greater as specified in the NEXCOM SRD, section 3.3.7.3.2, in accordance with NAS-SR-1000, section 3.2.1c.
- the NEXCOM system equipment has an inherent availability of 0.999975 or greater as specified in the NEXCOM SRD, section 3.3.7.3.3, and the NEXCOM RD, section 3.2.4.2, in accordance with NAS-SS-1000, Volume I, par. 3.2.4.

The high-level findings are the following:

- The RCAG MTBO and inherent availability requirements can be met with an RIU MTBF of 27,000 hrs. This is the minimum MTBF requirement for the RIU in order that the RCAG meet the RD MTBO requirement mentioned earlier. However, to add some “safety” margin, and to reduce the number of maintenance actions, an MTBF of 40,000 hrs is recommended.
- In all cases where a redundant GNI is assumed, a GNI MTBF of approximately 10,000 hrs is sufficient to meet the service availability requirements. However, a higher MTBF is recommended for the same reasons given for the RIU. It is not possible to meet the service availability requirements without GNI redundancy for any reasonable GNI MTBF values.
- In order to meet the En Route Voice and Data Service availability requirement of 0.99999, GNI redundancy is required; however, RIU redundancy is not required. In all cases BUEC is required in order that en route voice and data service meet the 0.99999 availability requirement. As long as BUEC is provided, this service availability can be met without a redundant and diverse ARTCC-to-RCAG telecommunications link. If BUEC is not provided, then adding a redundant and diverse ARTCC-to-RCAG telecommunications link can significantly improve the service availability.
- For En Route Data Service, in addition to the requirements of the previous bullet, redundancy is required for both A/G Router and LAN in order that En Route Data Service has an availability of 0.99999.
- In order to meet the Terminal Voice Service availability requirement of 0.99999 in the split main/standby (M/S) configuration, GNI redundancy is required and an RIU is required at both the main and standby sites. Redundancy of the RIU is not required.
- It is difficult to meet the Terminal Voice Service availability requirement of 0.99999 using the two-sited split transmitter/receiver (STR) configuration, even if the GNI and RIU are made redundant. Increasing the GNI MTBF from 10,000 hrs to 100,000 hrs and assuming GNI redundancy is still not sufficient to obtain a Terminal Voice Service availability better than 0.99998 for the two-sited STR configuration.
- Assuming a split M/S configuration in the terminal environment, if a high-availability WAN is available to connect the ATCT/TRACON to the ARTCC, then the A/G Router and the LANs in both control facilities must all be made redundant in order to achieve a Terminal Data Service availability

of 0.99999. If the WAN has a low availability, then it is not possible for Terminal Data Service to have an availability of 0.99999 even with redundancies provided in the various components.

The NEXCOM Segment 1 RD refers to NAS-SS-1000 and FAA Order 6040.15C for reliability, maintainability, and availability definitions. The next section discusses these definitions and points out some discrepancies.

E.1.1 RMA Definitions, Model Assumptions, and Modeling Approach

E.1.1.1 RMA Definitions

FAA Order 6040.15C and NAS-SS-1000 were both referenced in the NEXCOM RD as sources of RMA information. The NAS-SS-1000 provides its own RMA definitions. The RD references NAS-SS-1000 for RMA requirements yet references FAA Order 6040.15C for RMA definitions, which differ from the RMA definitions provided in NAS-SS-1000. This section points out the discrepancies and provides the rationale for the decisions regarding the selection of RMA definitions used for the analysis in this appendix.

The following definitions, not referenced in the RD, are provided in NAS-SS-1000, Volume I, Chapter 6 – Terms and Definitions:

Operational Availability: A measure of availability that includes the combined effect of item designs, application, operation, maintenance, and repair (including logistics travel time etc.). (This was used in the allocation of subsystem availability from the service availability goals in NAS-SR-1000).

Service/achieved availability: A measure of availability obtained as a result of measured field operating data (i.e., for identifying projected requirements, the service/achieved availability can be considered synonymous with operational availability).

Mean Time to Repair (MTTR): A basic measure of maintainability: the sum of corrective maintenance times, divided by the total number of failures within an item. Corrective maintenance is all actions performed as a result of failure in an end item. Corrective maintenance can include any or all of the following steps: localization, isolation, disassembly, interchange, reassembly, alignment, and checkout.

The discrepancies are the following:

- NAS-SS-1000 equates operational availability and service/achieved availability. However, the RD references FAA Order 6040.15C, par. 702 c, for the voice service availability definition. Par. 702 c is a definition for equipment and service availability. FAA Order 6040.15C, par 702 b, provides a definition for operational availability which differs from equipment and service availability. Operational availability as per FAA Order 6040.15C takes into account both scheduled and unscheduled outages, whereas equipment and service availability takes into account unscheduled outages only.
- NAS-SS-1000 and FAA Order 6040.15C give different definitions for MTTR. In NAS-SS-1000, MTTR *is mean time to repair* and **does not** include logistical time, travel time, or administrative time, etc. In FAA Order 6040.15C, MTTR is *mean time to restore* and **does** include logistical time, travel time, and administrative time, etc. For the RCAG MTBO requirement, the RD references FAA Order 6040.15C, par. 702f for MTTR used to compute MTBO, and specifies 0.5 hours for it. Since MTTR in FAA Order 6040.15C, par. 702f, includes logistical time, travel time, administrative time, etc., it does not make sense for it to be as small as 0.5 hours.

- Mean Down Time, instead of MTTR from NAS-SS-1000, corresponds to Mean Time To Restore from FAA Order 6040.15C.

Because of the discrepancies, an attempt was made to determine what was intended for the definitions of service availability and MTTR. The following bullets present the decisions made regarding the RMA definitions used for the analysis in this appendix.

- Service availability is computed using the NAS-SS-1000 definitions of MTTR and Mean Down Time. MTTR is used for all NEXCOM unique equipment, and Mean Down Time for all non-NEXCOM unique components (e.g., voice switches, telecommunications links, local- and wide-area networks, etc.). Mean Down Time includes all repair, logistical, travel, and administrative times. The set of assumptions in the next section provides a list of NEXCOM unique equipment.
- MTBO for the RCAG, as described in NEXCOM Segment 1 RD, section 3.2.2.2, in accordance with NAS-SS-1000, Volume I, par. 3.2.2.1, is determined using an MTTR of 0.5 hours, in accordance with NEXCOM Segment 1 RD, section 3.2.3.1. The 0.5 hours is applied to each piece of equipment at the RCAG, rather than to the entire RCAG.
- In order that the RCAG MTBO be at least 19,996 hours, the inherent availability for NEXCOM system equipment must be greater than 19,996 hours. The NEXCOM Segment 1 RD, section 3.2.4.2, requires NEXCOM system equipment to have an inherent availability of 0.999975 or greater. Using a 0.5 MTTR for NEXCOM system equipment, the inherent availability of 0.999975 translates into an MTBF of 19,996 hours. Thus, if each piece of equipment at the RCAG has an inherent availability of 0.999975, the RCAG MTBO would fall below 19,996 hours. The inherent availability requirement of 0.999975 is thus applied to the RCAG, rather than to each piece of equipment at the RCAG. In this way, the RCAG will meet the MTBO requirement of 19,996 hours.

E.1.1.2 Model Assumptions

The following modeling assumptions were made in the RMA computations:

- Data and voice are not considered as backups for each other.
- Voice switches are included for NEXCOM En Route and Terminal A/G Voice System availability computations.
- Controller-Pilot Data Link Communications (CPDLC) unique equipment, except for the A/G Router and the LANs in the ARTCC and ATCT/TRACON, is not included in the Data System availability computations.
- The time to access a backup or standby system is not included.
- Complete diversity between primary and backup paths is assumed.
- Service availability is computed independently for voice and data services on a per User Group basis
- The switchover from prime power to standby power is assumed perfect, i.e., the transfer switch is assumed to have an availability of 1 and the sensing and switchover time is assumed to be negligible.
- In the terminal environment, the same commercial power supply is assumed for all the different sites of the RTR (i.e., sites in the split M/S or STR configurations). Each separate site of the RTR is assumed to have separate battery backups.
- In the terminal environment, results are presented with and without the assumption of a voice switch bypass (VSBP) for the terminal voice switch (TVS). Both sets of results are presented to account for the different levels of ATCT/TRACONs. Most level 3 and above ATCT/TRACONs have VSBP, but most lower level ATCT/TRACONs do not.
- To compute the availability of non-NEXCOM unique equipment at a radio site, a 20 hr “restoral time” is used. To compute the availability of non-NEXCOM unique equipment at a control facility, a 2 hr “restoral time” is used. To compute the availability of NEXCOM unique equipment, the specified MTTR of 0.5 hrs is used. NEXCOM unique equipment includes: RIU, transmitters, receivers, timing source, timing reference, GNI.

- A “parallel” model is assumed for main and standby radios in the en route environment.
- A “parallel” model is assumed for primary and backup strings in the en route environment.
- A “parallel” model is assumed for main and standby strings of the split M/S configuration, and for transmitter and receiver strings of the STR configuration in the terminal environment.
- In the en route environment, all combinations of main and standby transmitters and receivers are possible. For example, main transmitter/main receiver, main transmitter/standby receiver, standby transmitter/main receiver, etc.
- A 3-hour Mean Down Time is used for the leased line or telecommunications link connectivity. This is the typical value seen in the current LINCS environment.
- Although there are several different ways used to configure RTR sites, two are considered in this appendix – the split M/S configuration using two sites, and the split transmitter/receiver (STR) configuration using two sites. There are four-site configurations used today, however, these are not analyzed. The two-site configurations provide a lower bound on the service availability that can be achieved, and are therefore sufficient to determine if the service availability requirements can be met for most of the other configurations.
- For the two communications paths to the two RTR sites (either split M/S or STR configurations) in the terminal environment, one communications path is assumed to be provisioned on airport cable and the other on low-density radio communications link (LDRCL). The LDRCL is assumed to be comprised of two LDRCL terminals (LDRCLTs) and one LDRCL repeater (LDRCLR). This LDRCL configuration is referred to as 2 LDRCLT + 1 LDRCLR
- Both cases of non-redundant and redundant telecommunications links to the RCAG are considered.
- Redundancy of communications lines to terminal radio sites is not considered.
- A failure of the Timing Reference does not lead to a failure of NEXCOM for at least 30 days, therefore, the Timing Reference is assumed to have an availability of 1.

E.1.1.3 Modeling Approach

The modeling approach is based on Method 1001, Conventional Probability, of MIL-STD-756B. This method requires developing a reliability block diagram (RBD) for each configuration considered and then determining the availability of the configuration using standard probability arguments. The same RBD and manipulations of the RBD for finding availability can be used to find MTBO.

E.2 Derivation of Relevant MTBFs/Availabilities

Table E-1 shows the data used in all of the analyses in this appendix. The RIU and GNI MTBF values have been parameterized. The other MTBF values are predicted values, generic values, or values estimated from field data (FAA outage data or FAA personnel expertise). The analyses in this appendix will determine the MTBFs for the RIU and GNI. In addition, the analyses will also determine the RIU’s and GNI’s redundancy requirements.

Table E-1. MTBF (hrs)/Availability Data Used for Analysis

	MTBF (hrs)/ Availabilities	Predicted Data	FAA Outage Data	Field Data not Available from FAA Outage Data
Single Transceiver (6)	*26,280*	√		
Timing Source (16))	150,000	√		
Prime Power (2)	4,586-6,738			√
Backup Power (11)	43,800-61,320			√
Prime + Standby Power + Transfer Switch(5)	162,622		√	
RIU	*parameter*			
GNI	*parameter*			
A/G Router (9)	19,996			
Timing Reference (3)	1	√		
VHF Antenna (8)	43,800-61,320			√
Leased Line (4)	2,997			√
VSCS (12)	0.99999		√	
VTABS (13)	0.99986		√	
Terminal Voice Switch (15)	0.99749 to 0.99996		√	
VSBP (7)	0.99986		√	
LAN (1)	50,000	√		
LDRCL = 2 LDRCLT + 1				
LDRCLR (10)	0.998264		√	
WAN RMA1 (14)	0.9999971	√		
WAN RMA4 (14)	0.9979452	√		

Notes:

1. *Generic value from Reliability Handbook [1]*
2. *William Baker of ANM-473 indicates that commercial power outages occur several times per year at a radio site. State of Connecticut Dept. of Public Utility Control [ref…] shows that the average over a 6 year period (1992 – 1997) was 1.3 (no major storms) – 1.9 (major storms) commercial power outages per customer per year. This corroborates ANM-473's data that commercial power MTBO per customer is less than a year. As a conservative estimate, the State of Connecticut data is used for this analysis.*
3. *failure of Timing Reference does not degrade system performance for at least 30 days. For RMA analysis it is equated to an availability of 1.*
4. *Estimated from MCI data which shows that leased line end user location (EUL)-A to EUL-B has approximately 0.999 availability and 3 hr repair*
5. *Obtained from National Airspace System Performance Analysis System (NASPAS) data FY1998 [2]*
6. *SRD requirement – specified as 26,280 hrs for a transmitter/receiver combination (i.e., transmitter and receiver considered in series for reliability/availability purposes – meaning a failure in either one causes a radio failure*

7. *VSBP not NASPAS reportable. VTABS availability number is used for VSBP.*
8. *William Baker of ANM-473 indicates that antennas last 5-7 years.*
9. *SRD section 3.5.4.3.*
10. *Obtained from NASPAS data 6/97 – 5/98 [2]. The corresponding MTTR for 2 LDRCLT + 1 LDRCLR using NASPAS data is 63.7 hrs.*
11. *William Baker of ANM-473 indicates that batteries last 5-7 years. 5 years will be used for this analysis.*
12. *NASPAS data for FY1998 and FY2000.*
13. *NASPAS data for FY2000.*
14. *FAA Telecommunications Infrastructure (FTI) Screening Information Request (SIR), DTFA01-00-S-00FTI, Attachment J.1 (FAA Telecommunications Services Description).*
15. *NASPAS data for FY2000 (see Section E.4 for detailed information).*
16. *TNT Rubidium clocks have a predicted MTBF of 600,000 hours. Other manufacturers predict 20-22 years (approximately 175,000 to 190,000 hours). To be conservative, an MTBF of 150,000 hours is assumed for the time source.*

E.3 NEXCOM Voice System

In this section the NEXCOM Voice Systems for En Route and Terminal environments are analyzed with respect to their RMA requirements.

E.3.1 NEXCOM Voice System for En Route Environment

The NEXCOM voice system for the en route environment is comprised of a "primary" string and a "backup" string. Figure E-1 provides a high-level depiction of en route A/G communications strings.

The backup string provides backup for the primary string and would be accessed by the controller in the event of a primary string failure.

The RCAG facility contains main and standby radios and other equipment (power, Timing Source, etc.) at the radio site and is connected by means of leased telecommunications links, in most cases, to the ARTCC.

The backup emergency communications (BUEC) facility is also connected to the ARTCC by means of leased telecommunications links, in most cases, and contains main radios (i.e., no standby), and other equipment.

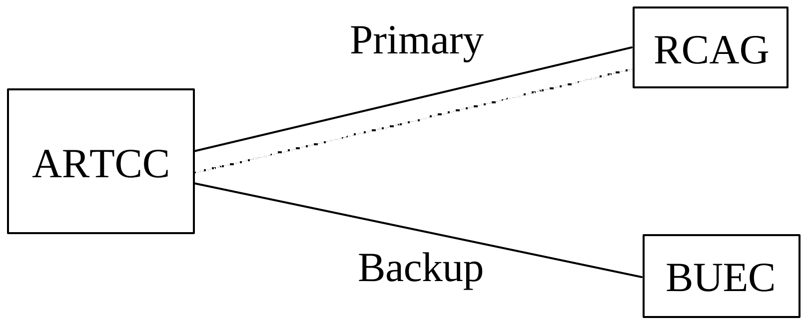


Figure E-1. High-Level En Route A/G Communications Strings

RCAG and BUEC facilities generally serve more than one controller. The RD requires that the RCAG MTBO be equal to or greater than 19,996 hours.

In this appendix, RCAG consists of the equipment at the primary remote radio site required to provide services to a single User Group. The following list and Figure E-2 (a) show the RCAG equipment required for a single User Group:

- RIU
- main transmitter
- standby transmitter
- main receiver
- standby receiver
- two VHF antennas
- prime power (i.e., commercial power)
- secondary power (i.e., battery backup)
- power transfer switch
- Timing Source
- Timing Reference

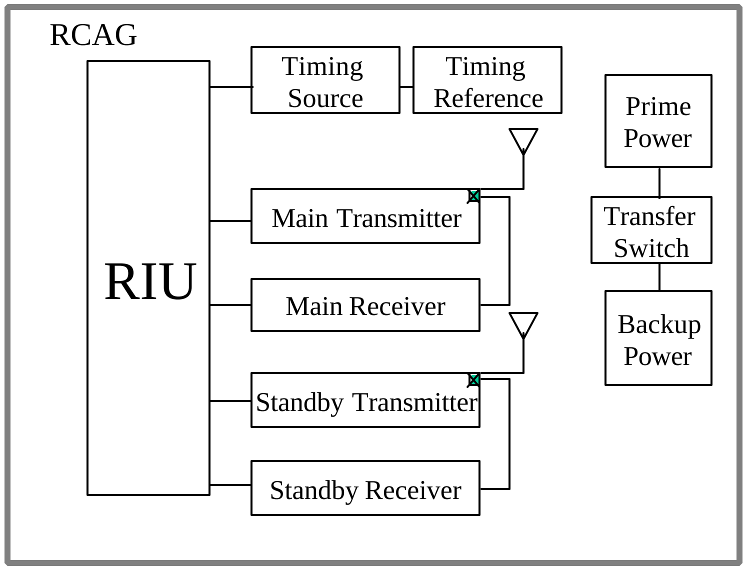
In addition, for the purpose of computing the RCAG MTBO, an RCAG outage is defined with respect to a single User Group and is defined as follows.

An RCAG outage is defined as a failure of the RCAG resulting in the inability of the controller to transmit or receive.

For example, if the main transmitter failed, but the controller can still transmit over the standby transmitter, then the main transmitter failure alone would not result in an RCAG outage.

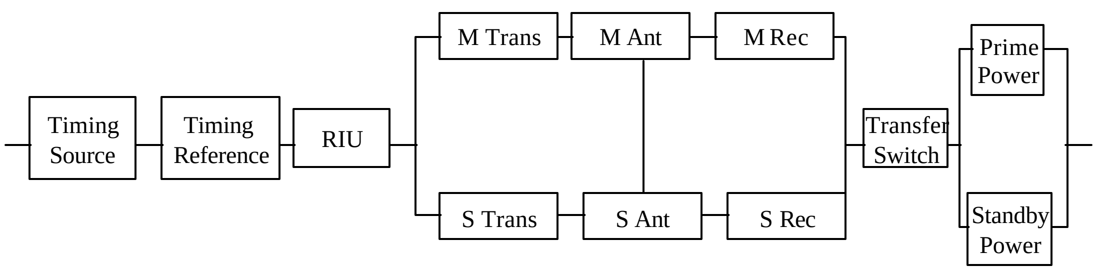
As another example, if the controller can transmit, but cannot receive from either main or standby receivers, then this would result in an RCAG outage.

Figure E-2 (b) shows the reliability block diagram (RBD) used to derive the RCAG MTBO and also used for the calculation of A/G voice service availability.



(a) RCAG Physical Configuration

Comment: The Timing Source is connected to a Timing Reference in our NEXCOM Model. The Timing Source is part of the NEXCOM system, the Timing Reference is not part of the NEXCOM system, although it is unique to NEXCOM.

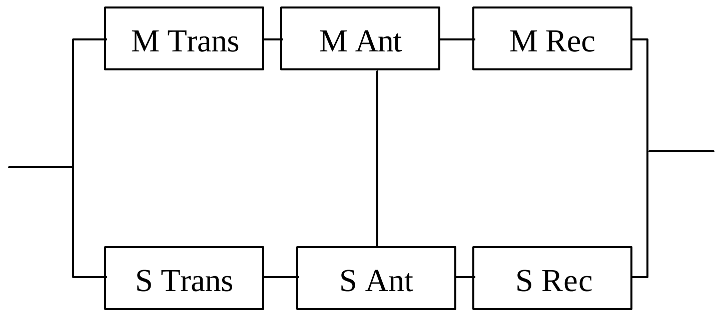


(b) RCAG Reliability Block Diagram

Figure E-2. RCAG for RMA Analysis

To avoid confusion, an explanation of the RCAG transmitter/receiver/antenna subsystem RBD (s-RBD) is in order as the connectivity lines are not physical connections. That portion of Figure E-2 is reproduced here.

s-RBD



This s-RBD allows for any combination of transmitter with receiver as stated in the assumptions previously. For example, it allows: the main transmitter to be used with the standby receiver in the event of a main receiver failure; the standby transmitter to be used with the main receiver in the event of a main transmitter failure, etc.

This s-RBD is a complex series-parallel combination as defined in MIL-STD-756B. However, this s-RBD will have a “simple” series and/or parallel configuration in certain states of a subset of its components. There are only two possible states for each component – a success state and a failure state. If a component is in a success state, it is assumed to have an availability of 1; otherwise, it is assumed to have an availability of 0. If a component is in a success state, it is short circuited in the s-RBD. If a component is in a failure state, it is open circuited in the RBD.

All possible success and failure states of the chosen components must be considered. The components are chosen so that the s-RBD with the chosen components in any combination of success or failure states has a simple series and/or parallel configuration. This is done because it is a straightforward procedure to find availabilities (and MTBOs) for series and parallel configurations. Once the availabilities of the s-RBD in all possible states of the chosen components are found, these availabilities are multiplied by the corresponding state probabilities. These products are summed to find the availability of the s-RBD. This procedure is described and applied to an example in MIL-STD-756B, section 2.1.3.1, pg. 1001-5, D-2. The components chosen for the above s-RBD are the two antennas.

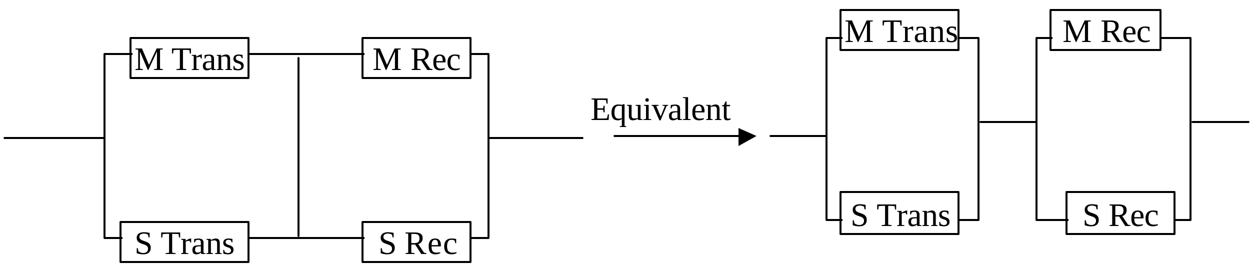
The above process is now applied to the above s-RBD. By going through this process, it becomes apparent how the s-RBD can accommodate the different transmitter/receiver combinations. As mentioned above, these states are also used to facilitate the computation of the RCAG availability. There are four possible states of the two antennas:

Both antennas are operational
The main antenna has failed, but the standby antenna is operational
The standby antenna has failed, but the main antenna is operational
Both antennas have failed

State 1. Both antennas are operational:

The probability of being in this state is $A_{Ant\_M} A_{Ant\_S}$

In this state, the s-RBD can be redrawn as the figure below on the left to represent the case where the antennas have availability of 1. However, the left figure is equivalent to the right figure which is a parallel combination of transmitters in series with a parallel combination of receivers. The implication of this configuration is that any combination of transmitter and receiver can be used as long as both antennas are operational. It also implies that a loss of either transmit or receive functionality implies a loss of service from the RCAG. The availability and MTBO of this configuration are easy to compute since this configuration is a parallel combination in series with another parallel combination.

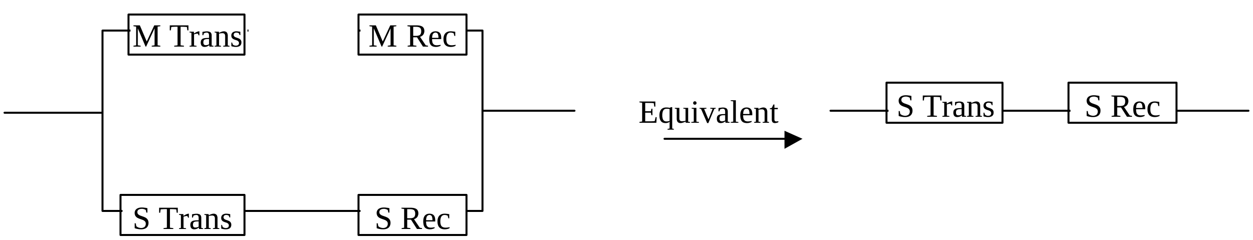


$$A_{State1} = (A_{M\ Tr} + A_{S\ Tr} - A_{M\ Tr}A_{S\ Tr})(A_{M\ \mathrm{Re}\ c} + A_{S\ \mathrm{Re}\ c} - A_{M\ \mathrm{Re}\ c}A_{S\ \mathrm{Re}\ c})$$

State 2. The main antenna has failed, but the standby antenna is operational.

The probability of being in this state is $(1 - A_{M\ Ant})A_{S\ Ant}$

In this state, the only operational communications path is through the standby transmitter and receiver as the equivalence of the configurations show. Also, whenever, the standby transmitter or receiver fails, there is a loss of service from the RCAG. Since the equivalent configuration is two single elements in series, the computation of availability (MTBO) is just the product (inverse of the sum) of the availabilities (failure rates) of the standby transmitter and standby receiver.

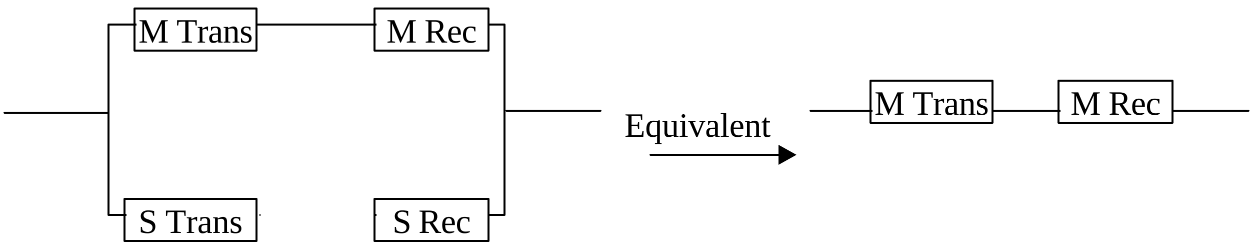


$$A_{State\,2} = A_{S\ Tr}A_{S\ \mathrm{Re}\ c}$$

State 3. The standby antenna has failed, but the main antenna is operational:

The probability of being in this state is $(1 - A_{S\ Ant})A_{M\ Ant}$

In this state, the only operational communications path is through the main transmitter and receiver as the equivalence of the configurations show. Also, whenever, the main transmitter or receiver fails, there is a loss of service from the RCAG. This state is similar to the previous state and the computations of MTBO and availability are similar.



$$A_{State3} = A_{M\ Tr} A_{M\ \mathrm{Re}\ c}$$

State 4. Both antennas have failed.

The probability of being in this state is $(1 - A_{S\ Ant})(1 - A_{M\ Ant})$

In this state there is no service from the RCAG, i.e., communications through the RCAG is not possible.

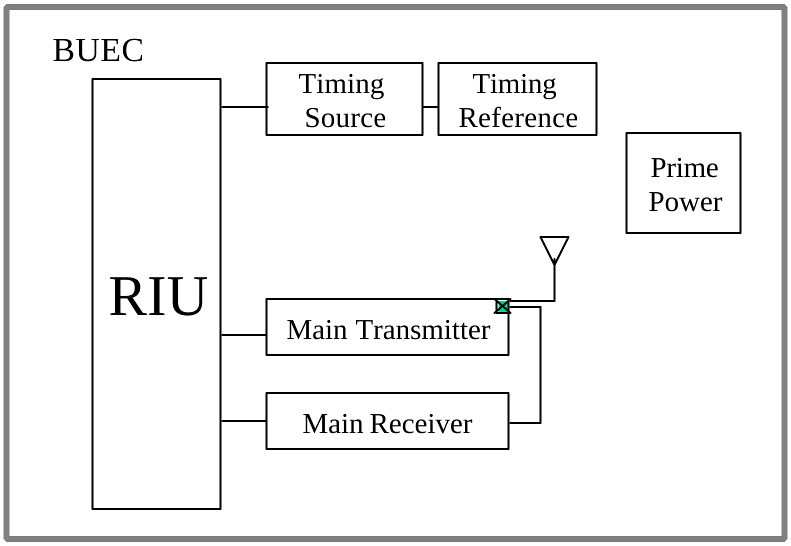
$$A_{State4} = 0$$

The availability of the transmitter/receiver/antenna s-RBD is then found as:

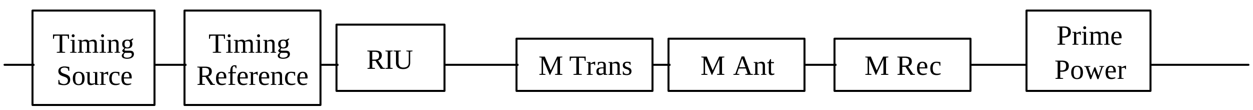
$$A_{s-RBD} = A_{M\ Ant} A_{S\ Ant} A_{State1} + (1 - A_{M\ Ant}) A_{S\ Ant} A_{State2} + (1 - A_{S\ Ant}) A_{M\ Ant} A_{State3}$$

Figure E-3 and the following list provide the equipment for the BUEC:

- RIU
- main transmitter
- main receiver
- VHF antenna
- prime power
- Timing Source
- Timing Reference



(a) BUEC Physical Configuration



(b) BUEC Reliability Block Diagram

Figure E-3. BUEC for RMA Analysis

Because there may be cases where an RCAG is not provided a BUEC backup, an RMA analysis of the primary connectivity alone is provided. The availability of the primary connectivity would then correspond to the voice service availability of the RD.

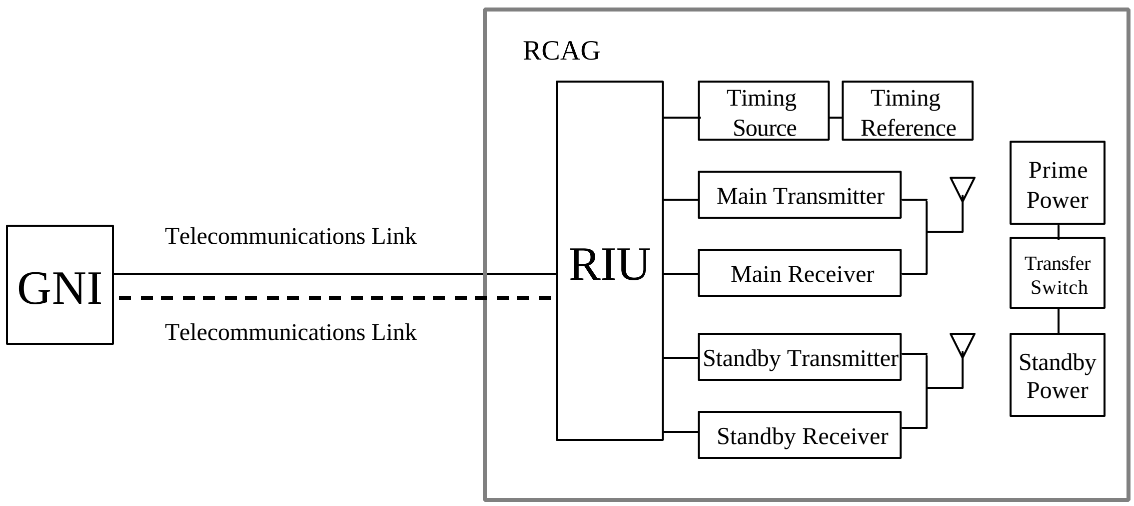
Figure E-4 shows the primary connectivity, which consists of the RCAG plus the telecommunications link connectivity to the ARTCC. The RMA analysis is performed with and without telecommunications link backup for connectivity between the ARTCC and its RCAG. In Figure E-4 a dashed line is used to indicate a backup telecommunications link.

The NEXCOM En Route A/G Voice System shown in Figure E-5 is the ground component that provides the NEXCOM En Route Voice Service. The NEXCOM En Route Voice System contains both the primary and backup (or BUEC) radio sites. The NEXCOM En Route Voice System availability would then correspond to the En Route Voice Service availability.

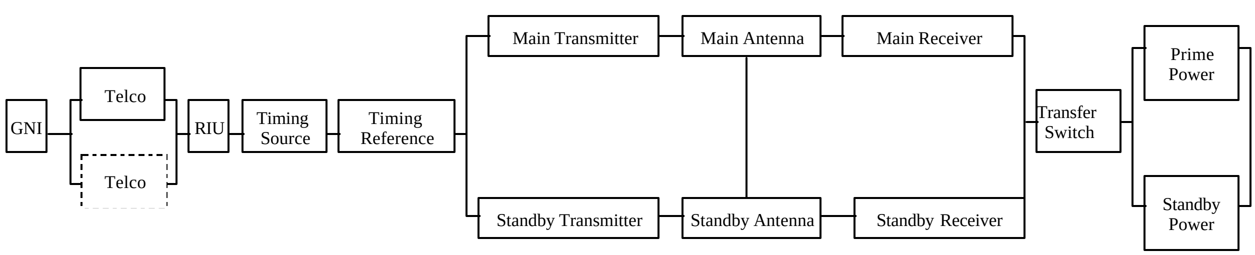
Figure E-5a shows the type of GNI redundancy considered in this appendix where one GNI serves the RCAG, and the other GNI serves the BUEC. In the event of a failure of the GNI which serves the RCAG, the controller must select the BUEC.

There are other ways in which GNI redundancy can be achieved. For example, each GNI could be used to access both the RCAG and the BUEC. In this case if the controller were using the RCAG, and the currently used GNI failed, an automatic switchover to the redundant GNI would allow the controller to continue using the RCAG.

In the GNI model used in this analysis, a GNI used to serve an RCAG cannot be used to serve the BUEC. Thus, the GNI-redundancy model used in this analysis is a worst-case model. This model is used in the en route environment for both voice and data. In the terminal environment a similar GNI-redundancy model is used and is described in a later section.

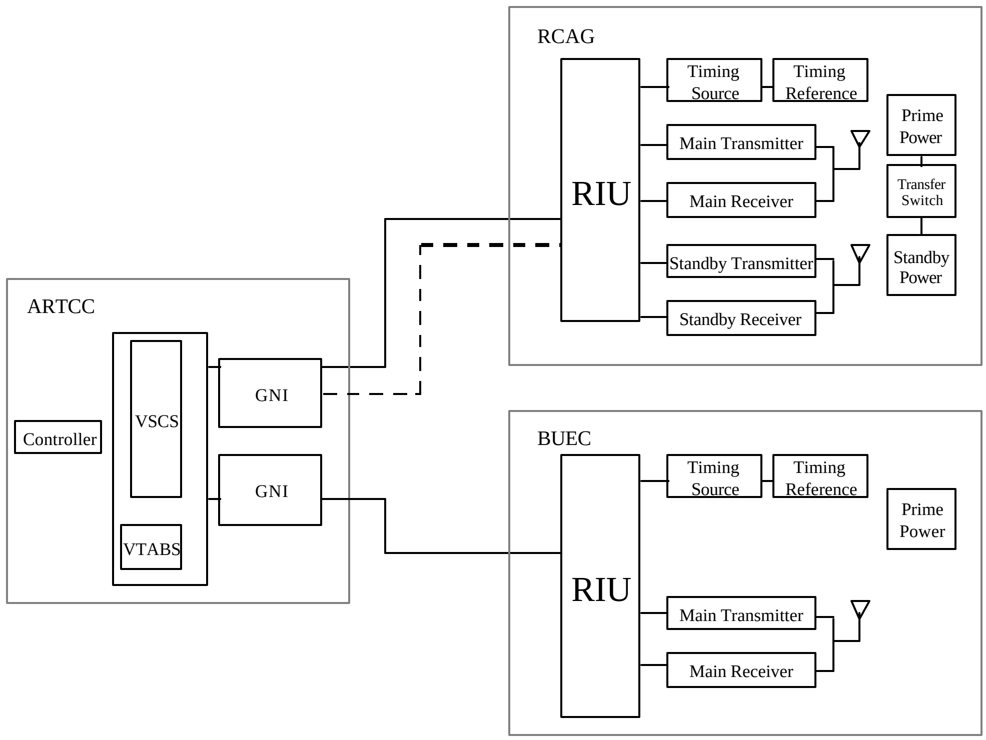


(a) Physical Configuration

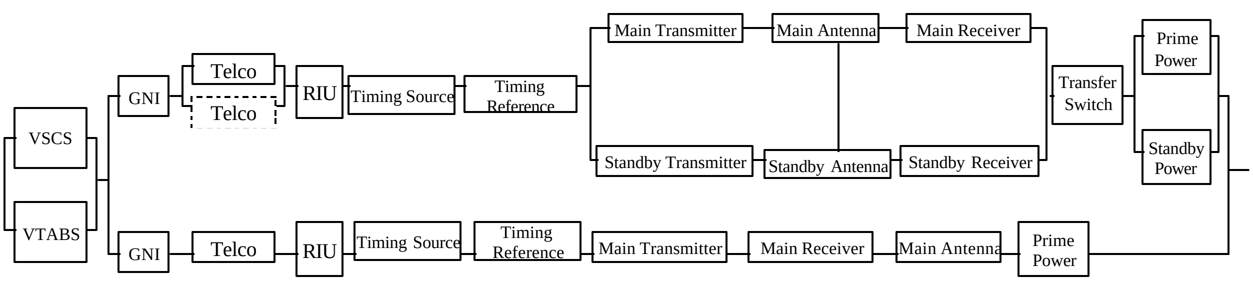


(b) Reliability Block Diagram

Figure E-4. Primary Path for NEXCOM En Route A/G Communications Subsystems



(a) Physical Configuration



(b) Reliability Block Diagram

Figure E-5. NEXCOM En Route A/G Voice System

E.3.1.1 NEXCOM RMA Requirements

Table E-2 summarizes the RMA requirements as specified in the NEXCOM RD. This appendix assumes that this overall service availability requirement applies to both the terminal and en route domains and for both voice and data A/G services, as both are assumed to be critical services.

Table E-2. RD Requirements

	MTBF (hrs)	MTBO (hrs)	MTTR* (hrs)	Availability
RCAG		≥ 19,996	≤ 0.5 (inherent)	
Transceiver	≥ 26,280			
Equipment				≥ 0.999975 (inherent)
Service Availability**				≥ 0.99999

**According to NAS-SS-1000 definition and not FAA Order 6040.15C definition*
***Voice or data (data service availability not specified in the RD, but is specified in NAS-SR-1000)*

E.3.1.2 NEXCOM En Route Voice Service RMA

E.3.1.2.1 NEXCOM RCAG MTBO and Inherent Availability Requirements

The RBD of Figure E-2 (b) is used to determine the MTBO of the RCAG. Once the RIU MTBF has been determined, this value will be used for the rest of the analyses to determine the GNI MTBF and the need for RIU and/or GNI redundancy so that the service availability requirements can be met.

Note that "MTBO" as used here should more appropriately be MTBF because 0.5 hrs, instead of an operational "restoral time", is used for each component of the RCAG in computing the RCAG "MTBO" as required by the RD. Thus, the second column of Table 3 is labeled "MTBF" instead of "MTBO." Later references in this appendix for this particular RCAG requirement will continue to refer to it as the "RCAG MTBO" requirement to avoid confusion with the RD.

Table E-3 shows the RCAG MTBF results for the NEXCOM RCAG and shows that with an RIU MTBF of 26,889 hrs, the RCAG with a single RIU, will meet the MTBF requirement of 19,996 hrs. and the inherent availability requirement of 0.999975. Note that this result is based on the assumption that the MDR/RIU has the capability to "coast", in the event of a Timing Reference failure, without performance degradation for a period of at least 30 days and 30 days should be long enough to restore the Timing Reference operation.

For the remaining analysis in this appendix, an RIU MTBF of 40,000 hrs will be used as this value is sufficient to meet the requirements and provides some margin.

Table E-3. Determining RIU MTBF for Meeting NEXCOM RCAG Requirements Coasting is Considered Mitigator of Timing Source Failure (Based on Inherent MTTR of 0.5 hrs)

RIU MTBF (hrs)	NEXCOM RCAG MTBF** (hrs)	NEXCOM RCAG Inherent Availability
26,280	19,658	0.999980974
26,889	19,996	0.999981405
30,000	21,667	0.999983334
40,000	26,442	0.99998750

*MTBF for transmitter and receiver in series = 26,280 hrs.
**Corresponds to the RCAG MTBO requirement

E.3.1.2.2 En Route Primary Connectivity

There may be cases where it is not possible to provide BUEC coverage of a sector for a variety of reasons. This section was written mainly to cover this situation. Table E-4 shows the resultant MTBO of the primary connectivity (or the primary string), with varying GNI MTBFs. The primary connectivity includes the path from the GNI to the antennas at the radio site. Table 4 considers two cases: a single telecommunications link connecting the ARTCC GNI and RCAG; and diverse and redundant telecommunications links connecting the ARTCC GNI and RCAG.

Table E-4 also shows the number of primary string failures per year that would result. This is also the number of times per year that the backup system (e.g., BUEC) would have to be accessed. As the GNI MTBF has not yet been determined, a range a values for the GNI MTBF is shown. It is apparent from Table E-4 that adding a redundant and diverse telecommunications link significantly increases the MTBO of the primary connectivity.

Tables E-5a and E-5b show the corresponding primary string availabilities, and also show the effect on the availability of providing a redundant RIU. Tables E-5a and E-5b show that there is not much of an improvement in availability by adding redundancy to the RIU.

Table E-5b shows that an order of magnitude improvement is obtained by adding a fully diverse redundant communications path between the GNI and the primary radio site. In addition, Table E-5b shows that an availability exceeding 0.9998 can be achieved for the primary connectivity when redundant and diverse telecommunications links are provided.

Table E-4. MTBO for Primary Connectivity of the A/G Communications Subsystems
Single-Threaded Primary Connectivity

GNI MTBF (hrs)	MTBO (hrs) A/B*	Number Failures per Year for Entire Primary Connectivity A/B*	Number of Failures per Year Due to Leased Line Failures Only A/B*
10,000	2,121/7,218	4.1/1.2	2.9/0.006
27,000	2,448/13,232	3.6/0.66	2.9/0.006
30,000	2,470/13,913	3.6/0.63	2.9/0.006
40,000	2,522/15,738	3.5/0.56	2.9/0.006
100,000	2,621/20,602	3.3/0.42	2.9/0.006

MTBF for transmitter and receiver in series assumed to be 26,280 hrs.

RIU – 40,000 hrs. MTBF
***A = Single Telecommunications Link Connectivity**
***B = Redundant Telecommunications Link Connectivity**

Table E-5a. Availability for Primary Connectivity (GNI-to-RCAG)
Single-Threaded Primary Connectivity

GNI MTBF (hrs)	With Single RIU	With Redundant RIU
10,000	0.99881	0.99881
27,000	0.99884	0.99886
30,000	0.99884	0.99886
40,000	0.99885	0.99886
100,000	0.99886	0.99887

MTBF for transmitter and receiver in series

RIU – 40,000 hrs MTBF

Table E-5b. Availability for Primary Connectivity (GNI-to-RCAG)
Redundant Telecommunications Links

GNI MTBF (hrs)	With Single RIU	With Redundant RIU
10,000	0.99882	0.99982
27,000	0.99984	0.99985
30,000	0.99984	0.99986
40,000	0.99985	0.99986
100,000	0.99985	0.99987

MTBF for transmitter and receiver in series RIU – 40,000 hrs. MTBF

E.3.1.2.3 Corrective Maintenance for Average En Route Primary Site

There are currently approximately 3 circuits per en route radio site. For the 2V2D configuration of VDL Mode 3, 2 pairs of M/S MDRs would be required to support 3 circuits. The results are presented for all equipment and also for NEXCOM unique equipment. The equipment at this average site would include:

- 2 RIUs (NEXCOM Unique)
- 2 transmitters (M+S), 2 receivers (M+S) per RIU = 8 radio units (NEXCOM Unique)
- 2 VHF antennas per RIU = 4 VHF antennas
- 1 Timing Reference per RIU = 2 Timing References (NEXCOM Unique) (Not part of the NEXCOM System)
- 1 Timing Source per RIU = 2 Timing Sources (NEXCOM Unique)
- 1 prime power unit per site
- 1 standby power unit per site

Table E-6 shows the Mean Time Between (Corrective) Maintenance Actions (MTBMA) and the corresponding number of corrective maintenance actions that would be required per year for a NEXCOM en route radio site supporting 3 circuits. The results in Table E-6 assume that maintenance personnel are sent to the radio site whenever any item fails regardless of whether there is a standby unit. For different Mean Down Times, the results are approximately the same.

Table E-6. Corrective Maintenance for NEXCOM En Route Radio Site Supporting 3 Circuits

MTBMA* (hrs)	Number Corrective Maintenance Actions per Year for all Equipment at RCAG	Number of Corrective Maintenance Actions per Year for NEXCOM-Unique Equipment Only
1,751	5.0	2.0

*Mean Time Between (Corrective) Maintenance Actions
RIU – 40,000 hrs. MTBF

E.3.1.2.4 Probability of Standby Unit Failure During Repair Time of Main Unit

Of interest is also the probability that the standby transmitter (receiver) will operate without failure during the repair time of the failed main transmitter (receiver). With a radio unit (transmitter or receiver) MTBF of 52,560 hrs. (i.e., transmitter + receiver MTBF of 26,280 hrs.), the probability that the standby transmitter (receiver) will operate without failure during the Mean Down Time of the main transmitter (receiver) ranges from 0.999924 for an optimistic 4 hour Mean Down Time to 0.999620 for a Mean Down Time of 20 hours (i.e., the probability of a standby failure during the Mean Down Time of the same-type main radio unit is 7.6×10^{-5} for a Mean Down Time of 4 hours and 3.8×10^{-4} for a Mean Down Time of 20 hours).

E.3.1.2.5 NEXCOM En Route System Availability

The last requirement addressed in this appendix for en route voice is the requirement that NEXCOM En Route System availability (i.e., equivalent to the RD’s voice service availability) equal or exceed 0.99999. As the GNI MTBF has yet to be determined, the service availability requirement is calculated for a range of GNI MTBF values.

Also, an important consideration with regard to the RIU is its redundancy requirements. The redundancy of the RIU has little effect on the overall service availability (i.e., when both primary and backup connections are taken into account) as can be seen by comparing the last two columns of Table E-7.

However, Table E-7 does show that adding redundancy and diversity to the communications path substantially increases the service availability.

Additionally, with an RIU failure, the controller can still access the backup radio site. This means that the RIU is not a common point of failure for en route communications service. Thus, RIU redundancy is neither required to satisfy FAA Diversity Order 6000.36 nor the service availability requirement.

Table E-7 also shows that the service availability requirement can be met with a GNI MTBF of 10,000 hrs, and increasing the GNI MTBF to 100,000 hrs does not significantly increase the service availability. Although a GNI MTBF of 10,000 hours may suffice to satisfy the service availability requirements, consideration must be given to the number of maintenance actions that an MTBF of 10,000 hrs would engender. This is discussed in a later section of this appendix.

Table E-7. NEXCOM En Route A/G System Availability

GNI MTBF (hrs)	NEXCOM En Route System Availability* A/B*** Single RIU**	Redundant RIU**
10,000	0.99999301/0.99999888	0.99999310/0.99999896
27,000	0.99999323/0.99999907	0.99999332/0.99999915
30,000	0.99999325/0.99999909	0.99999333/0.99999916
40,000	0.99999328/0.99999911	0.99999336/0.99999918
100,000	0.99999333/0.99999915	0.99999340/0.99999923

***RF link and avionics not included**
****RIU MTBF = 40,000 hours**
*****A = Single-threaded connectivity to primary site**
*****B = Redundant connectivity to primary site**

E.4 NEXCOM Terminal A/G Voice System

There are several radio site configurations used for the current terminal A/G voice communications system. Two are considered in this appendix. Figure E-5 shows the split main/standby configuration where the main radios are at one location on the airport grounds and the standby radios are at another location. Figure E-6 shows the split transmitter/receiver (STR) configuration where main/standby transmitters are at one location on the airport grounds and main/standby receivers are at a different location. Only the two-sited configurations are considered in this appendix. There are three- and four-sited configurations as well. The two-sited results provide a lower bound on the service availability that can be achieved.

In Figure E-6, there is a single RIU at the transmitter site. The main transmitter and main receiver, although at different sites, are connected to the same RIU. The same is true for the standby transmitter and standby receiver. Airport transmission media are required to connect the receivers to the RIU at the transmitter site.

There are two GNIs for redundancy of the same type described for the en route environment. One GNI serves the main radio, and the other serves the standby radio. As in the en route environment, there are other ways to provide GNI redundancy. The model considered here is a worst case in that there is a "main" GNI and a "standby" GNI. The "main" GNI cannot be used to access the standby radio, and vice versa.

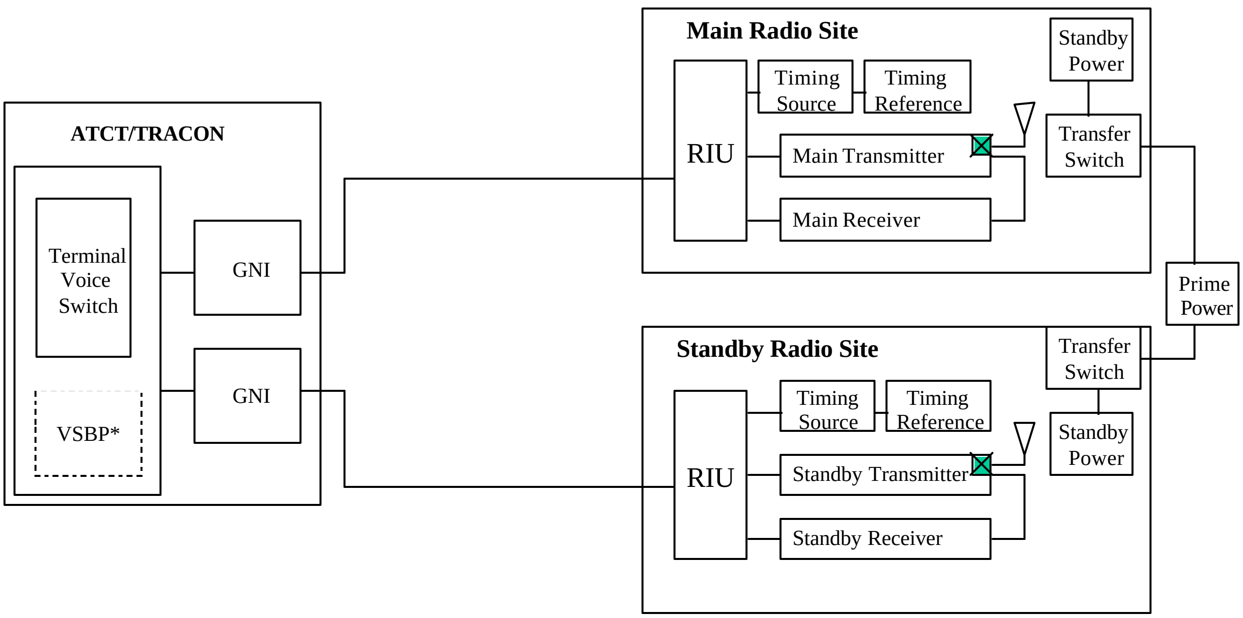
Each GNI has an airport transmission medium connecting it to the RIU at the transmitter site. One transmission medium from the GNI is used to access the main transmitter through the RIU. The other transmission medium from the GNI is used to access the standby transmitter through the RIU. For this particular configuration, the RIU is a common point of failure. Also, it would never be possible to achieve a service availability of 0.99999 for this configuration with any reasonable MTBF for the RIU.

Figure E-7 also shows the STR configuration, but where there are two RIUs at both transmitter and receiver sites. There are two GNIs. In this configuration, one GNI is used to access the main transmitter and main receiver through two direct connections. The other GNI is used to access the standby transmitter and standby receiver through two direct connections. The model assumes that only main transmitter/main receiver and standby transmitter/standby receiver combinations are possible. This assumption results in lower bound service availability estimates.

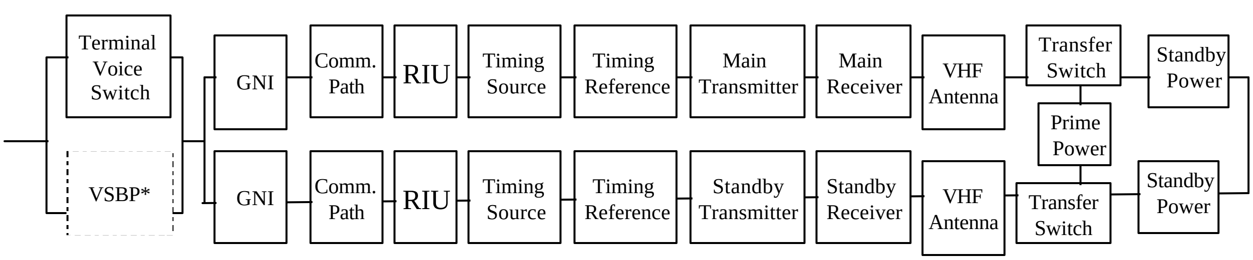
There are different types of voice switches used in the terminal area. Table E-8 shows the different switch types used, the number of each type used in the field, their availabilities over the past 3 years [4].

Over the past year, all the terminal switches had availabilities below 0.99999. However, many level 3 ATCT/TRACONs and above provide a VSBP for the voice switch. The analysis looks at two cases – VSBP is provided, and VSBP is not provided. This is done to cover all levels of ATCT/TRACONs.

As Table E-8 shows, the Terminal A/G voice switch availabilities for FY2000 range from 0.99995 down to 0.99749. The analysis is done using just two values, the worst case of 0.99749 and a nominal value of 0.9999.



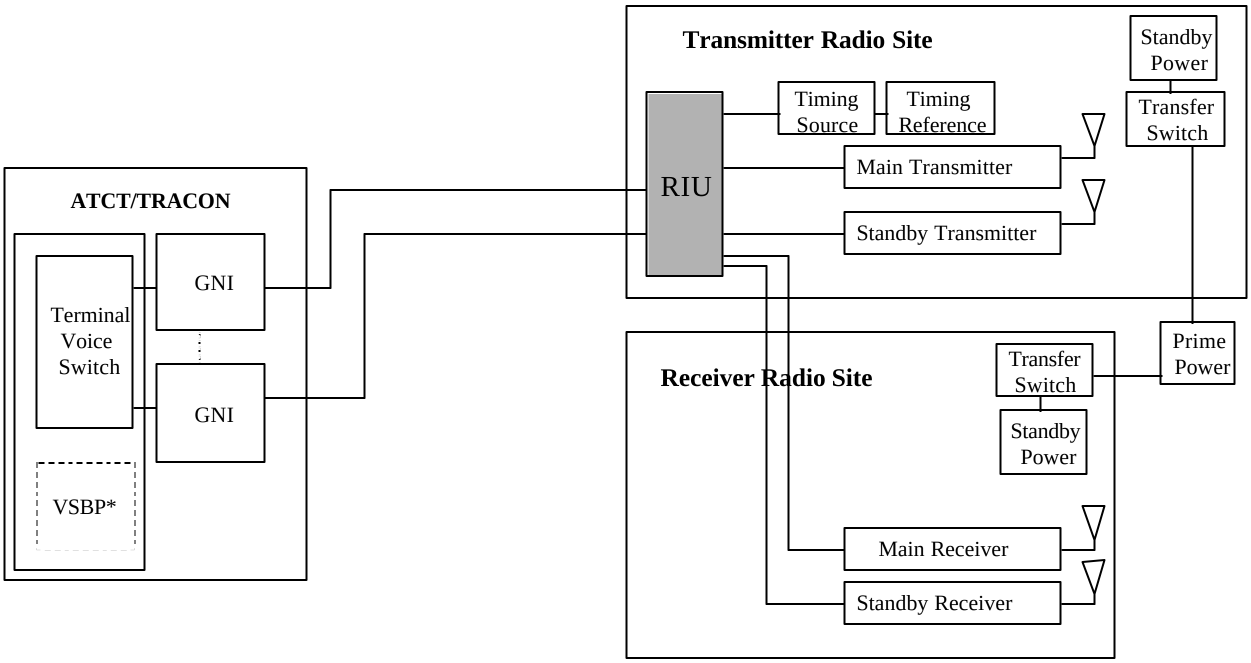
(a) Physical Configuration



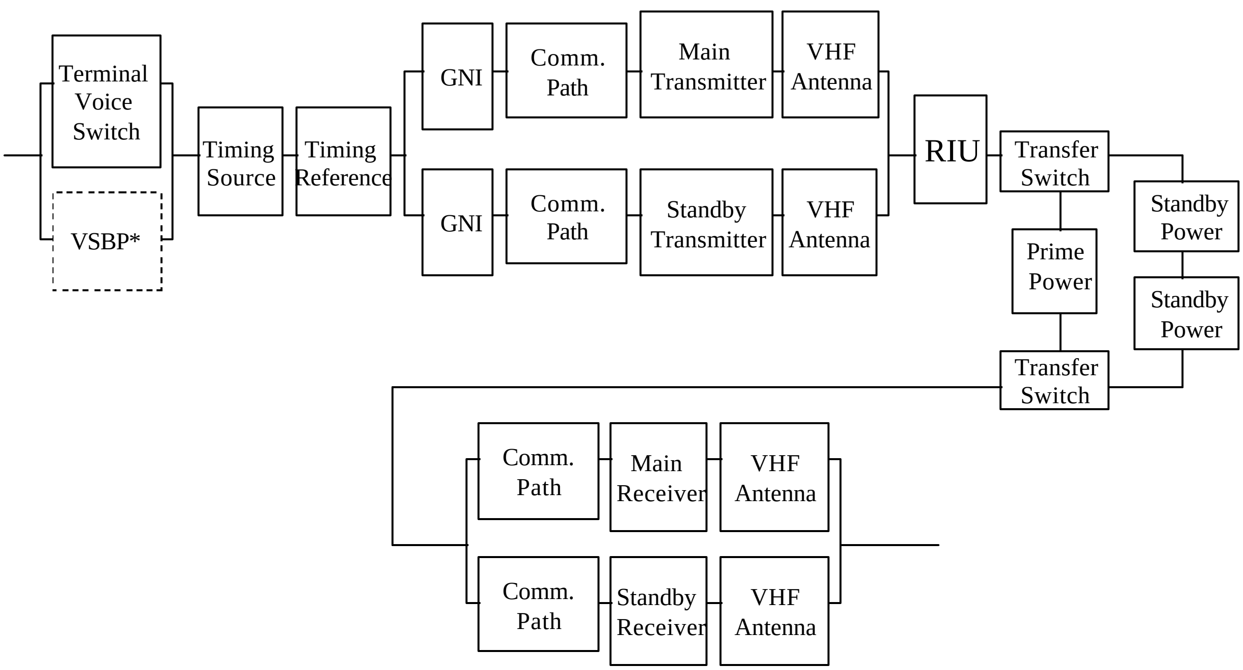
(b) Reliability Block Diagram

*Many Level 3 ATCT/TRACONs and Above

Figure E-5. NEXCOM Terminal A/G Voice System – Split Main/Standby



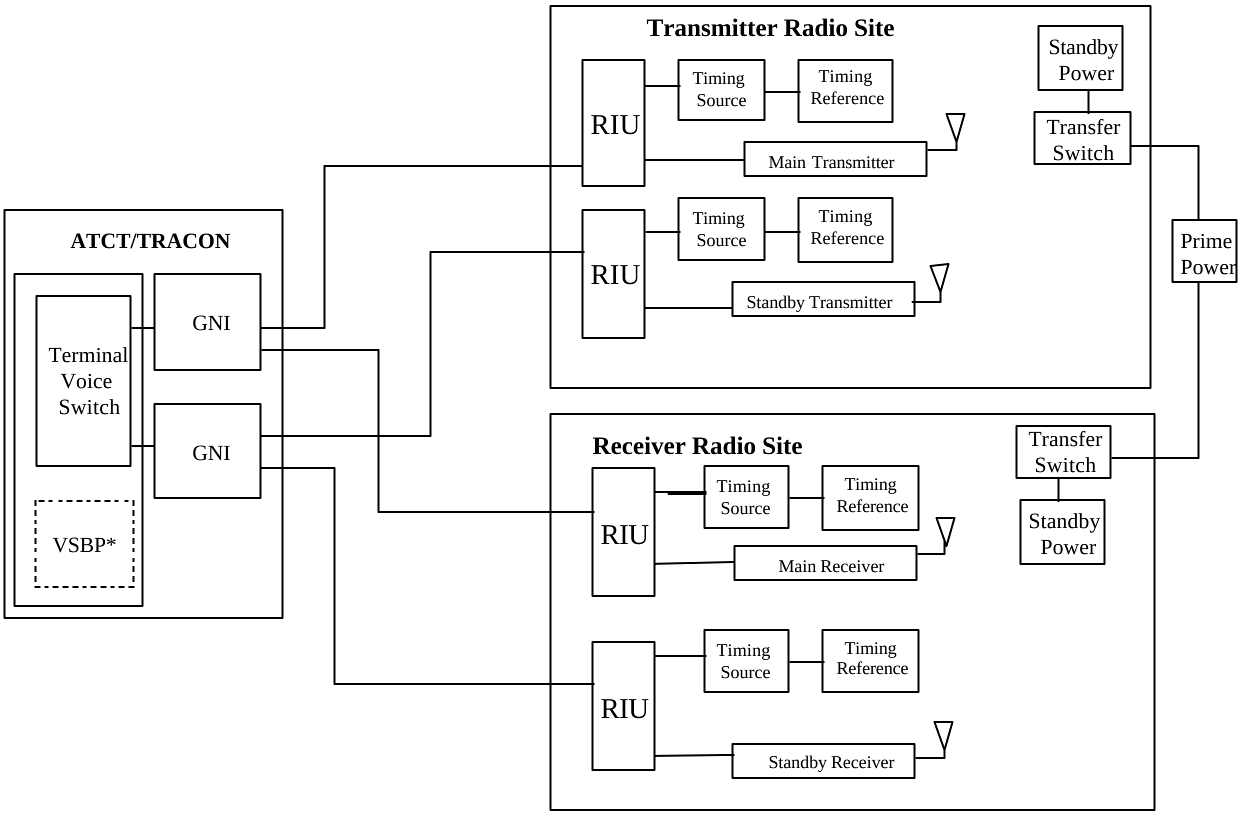
(a) Physical Configuration



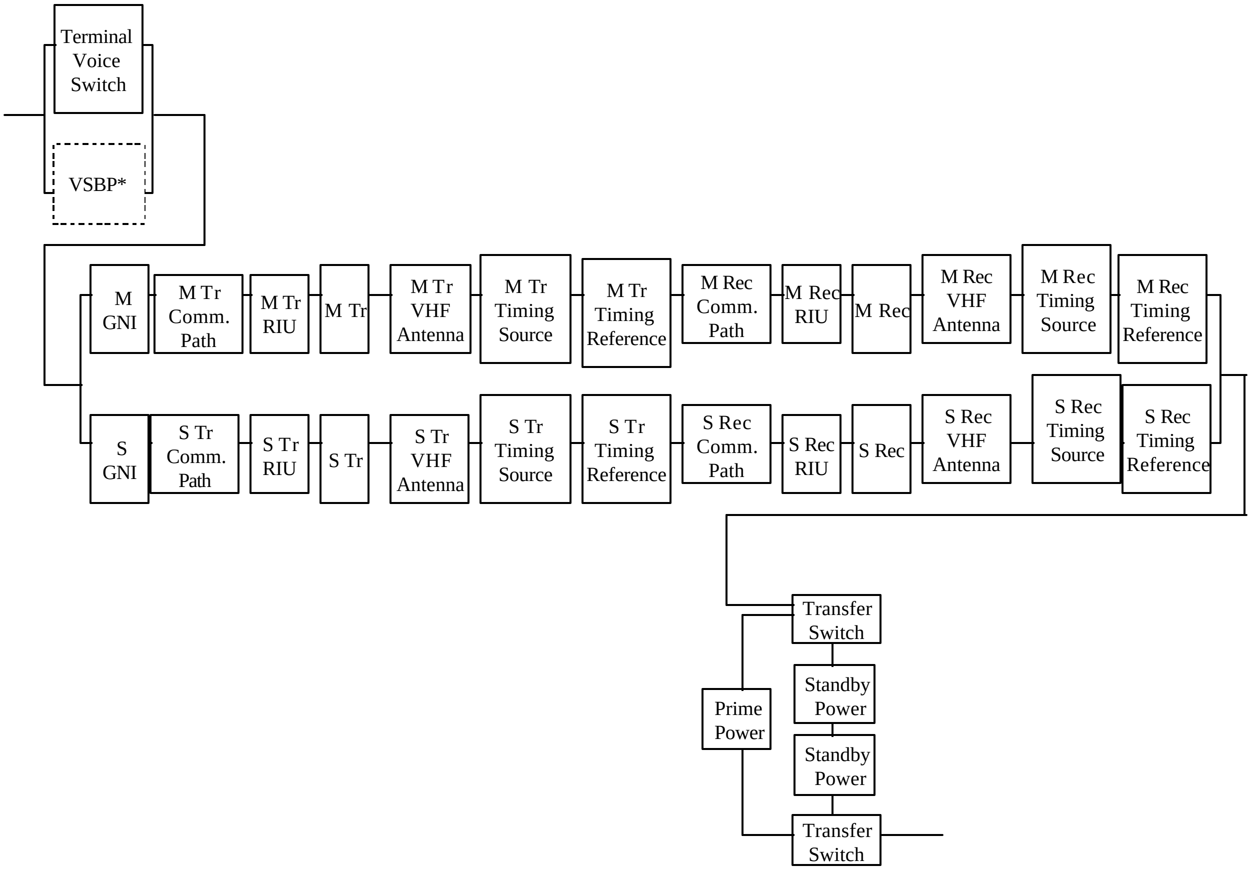
(b) Reliability Block Diagram

- *Many Level 3 ATCT/TRACONs and Above

Figure E-6. NEXCOM Terminal A/G Voice System – Split Transmitter/Receiver: Non-Redundant RIU



(a) Physical Configuration



(b) Reliability Block Diagram

- *Many Level 3 ATCT/TRACONs and Above

Figure E-7. NEXCOM Terminal A/G Voice System – Transmitter/Receiver Split: Redundant RIU

Table E-8 Terminal A/G Voice Switch Availabilities Over 3 Years

Switch Type	Year	Number of Switches**	Switch Availability*
ICSS48BA	03/98-02/99	173.417	0.99990
	03/99-02/00	165.667	0.99962
	03/00-02/01	157.167	0.99991
ICSS48BB	03/98-02/99	27.833	0.99993
	03/99-02/00	23.000	0.99993
	03/00-02/01	20.417	0.99749
ICSS48BC	03/98-02/99	68.250	0.99958
	03/99-02/00	63.083	0.99985
	03/00-02/01	62.667	0.99931
TVS48HA	03/98-02/99	146.167	0.99999
	03/99-02/00	150.083	0.99998
	03/00-02/01	151.417	0.99995
TVS48HB	03/98-02/99	4.083	0.99998
	03/99-02/00	6.833	1.00000
	03/00-02/01	28.5	0.99996
TVS48HC	03/98-02/99	58.083	0.99826
	03/99-02/00	70.500	0.99998
	03/00-02/01	80.917	0.99992

*As reported in NASPAS data FY1998, FY1999, FY2000
**Fractional values for numbers of switches because some switches not in place the whole year

An availability analysis was performed for the split M/S configuration shown in Figure E-5, and the STR configuration shown in Figure E-7. As mentioned earlier the STR configuration in Figure E-6 would have an availability less than 0.99999 because the RIU is a common point of failure, and has an availability that is less than 0.99999.

Table E-9 shows that without VSBP, 0.99999 cannot be achieved for Terminal A/G Service availability using either the split M/S or STR configurations.

Table E-10 shows that the split M/S configuration provides a higher availability than the STR configuration. Table E-10 also shows that it may be difficult to achieve a service availability of 0.99999 using the two-sited STR configuration in the terminal environment. This result is, of course, based upon the assumptions, but nevertheless, it should raise a flag regarding use in the terminal environment of the two-sited STR configuration.

Table E-9. NEXCOM Terminal Domain Voice Service Availability – No VSBP

GNI MTBF (hrs)	Split M/S*		Split Trans./Rec. (STR)**	
	TVS (0.9999)	TVS (0.99749)	TVS (0.9999)	TVS (0.99749)
10,000	0.999896485	0.997486493	0.999882016	0.99747206
27,000	0.999896604	0.997486612	0.99988225	0.997472293
30,000	0.999896611	0.997486619	0.999882264	0.997472307
40,000	0.999896626	0.997486635	0.999882295	0.997472337
100,000	0.999896654	0.997486663	0.99988235	0.997472393

* Split M/S configuration has an RIU both at main and standby sites
** STR configuration has 2 RIUs at transmitter site and 2 RIUs at receiver site

Table E-10. NEXCOM Terminal Domain Voice Service Availability – With VSBP

GNI MTBF (hrs)	Split M/S*		Split Trans./Rec. (STR)**	
	TVS (0.9999)	TVS (0.99749)	TVS (0.9999)	TVS (0.99749)
10,000	0.999996471	0.999996137	0.999982001	0.999981667
27,000	0.999996590	0.999996256	0.999982235	0.999981901
30,000	0.999996597	0.999996263	0.999982248	0.999981914
40,000	0.999996612	0.999996278	0.999982279	0.999981945
100,000	0.999996640	0.999996306	0.999982334	0.999982001

* Split M/S configuration has an RIU both at main and standby sites
** STR configuration has 2 RIUs at transmitter site and 2 RIUs at receiver site

E.5 Data System/Service

For data service, both the en route and terminal domains are analyzed. Unlike terminal A/G voice service, whose components are independent of those at the ARTCC, terminal data service relies upon components at both the ATCT/TRACON and the ARTCC. In the data service configurations analyzed, the assumption is that there is no RIU redundancy, since as seen in the A/G voice case above, RIU redundancy has little impact on the overall service availability. The same result can be expected for data service.

Also, unlike A/G voice service where the voice switch is included in the service availability computations, the data service unique equipment, except for the A/G Router and HID/NAS LAN, in the ARTCC, is not included in the data service availability computation. The A/G Router and HID/NAS LAN in the ARTCC are included because they are used for NEXCOM-specific purposes.

Currently, the communications service availability provided by the Controller-Pilot Data Link Communications (CPDLC) service in accordance with National Airspace Performance Reporting System, par. 702c, is specified to be 0.999 or greater on an individual sector basis, in accordance with - NAS-SS-1000, FAA NAS System Specification, Volume I, par. 3.2.1.2.8.1g [5]. In addition, CPDLC unique ground equipment is specified to have an inherent availability of 0.999 or greater. Further requirements are that no single point of failure of the CPDLC unique ground equipment shall cause a loss of service outage for more than 10 minutes, per paragraph 3.8.1, subparagraph c, d, & e, NAS SR-1000, FAA NAS System Requirements Document [6].

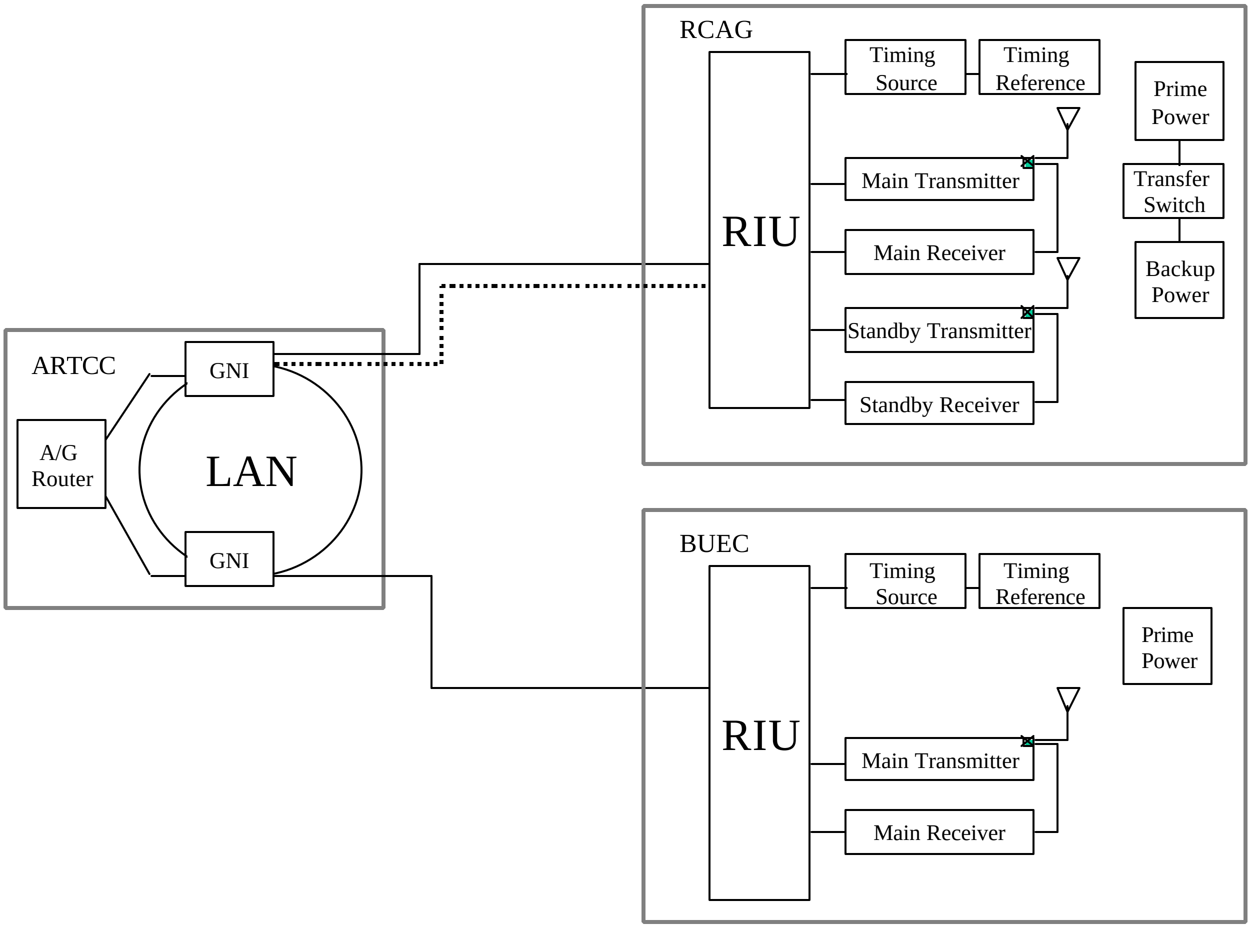
In order for the entire service, which includes the CPDLC unique ground equipment, to meet an availability of 0.99999, the CPDLC unique ground equipment must have an availability exceeding 0.99999. Based on the data system availability results provided in the following sections, the FAA can determine what the availability of the CPDLC unique equipment must be and if redundancy is required in order to meet an overall service availability of 0.99999. This will not be done here.

E.5.1 NEXCOM En Route Data System

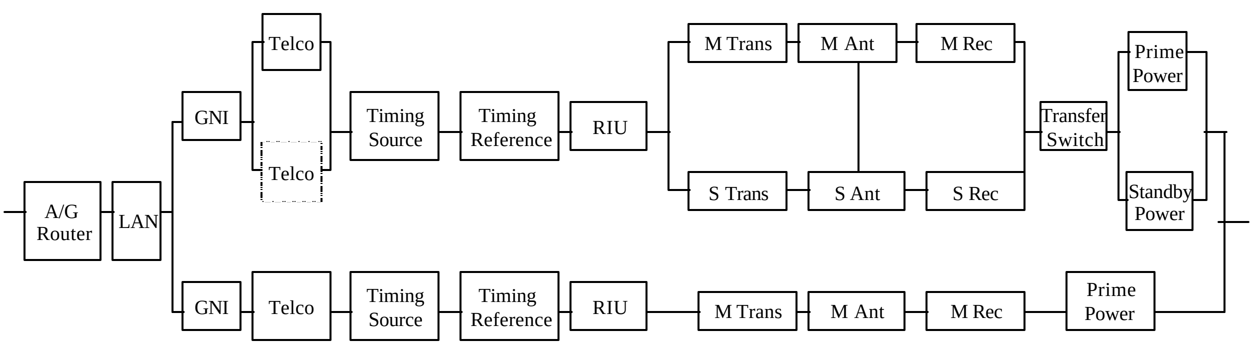
Figures E-8 and E-9 show possible connections for the En Route Data System for En Route Data Service assuming that NEXCOM VDL-3 is being used. In Figure E-8 no redundancy for the A/G Router or the HID/NAS LAN is provided. In Figure E-9 redundancy is provided for the A/G Router. Table E-11a, which assumes a non-redundant LAN, shows the resulting NEXCOM En Route Data Service Availabilities under different assumptions regarding A/G Router redundancy.

Table E-11a shows that the NEXCOM En Route Data Service availability would not meet the 0.99999 availability required of a critical service with redundancy provided for the A/G Router, but not for the LAN. With A/G Router redundancy alone, the data system availability falls between 0.9999 and 0.99999.

However, if the LAN is made redundant in addition to the A/G Router, then Table E-11b shows that an En Route Data Service availability of 0.99999 can be met even with non-redundant telecommunications links.

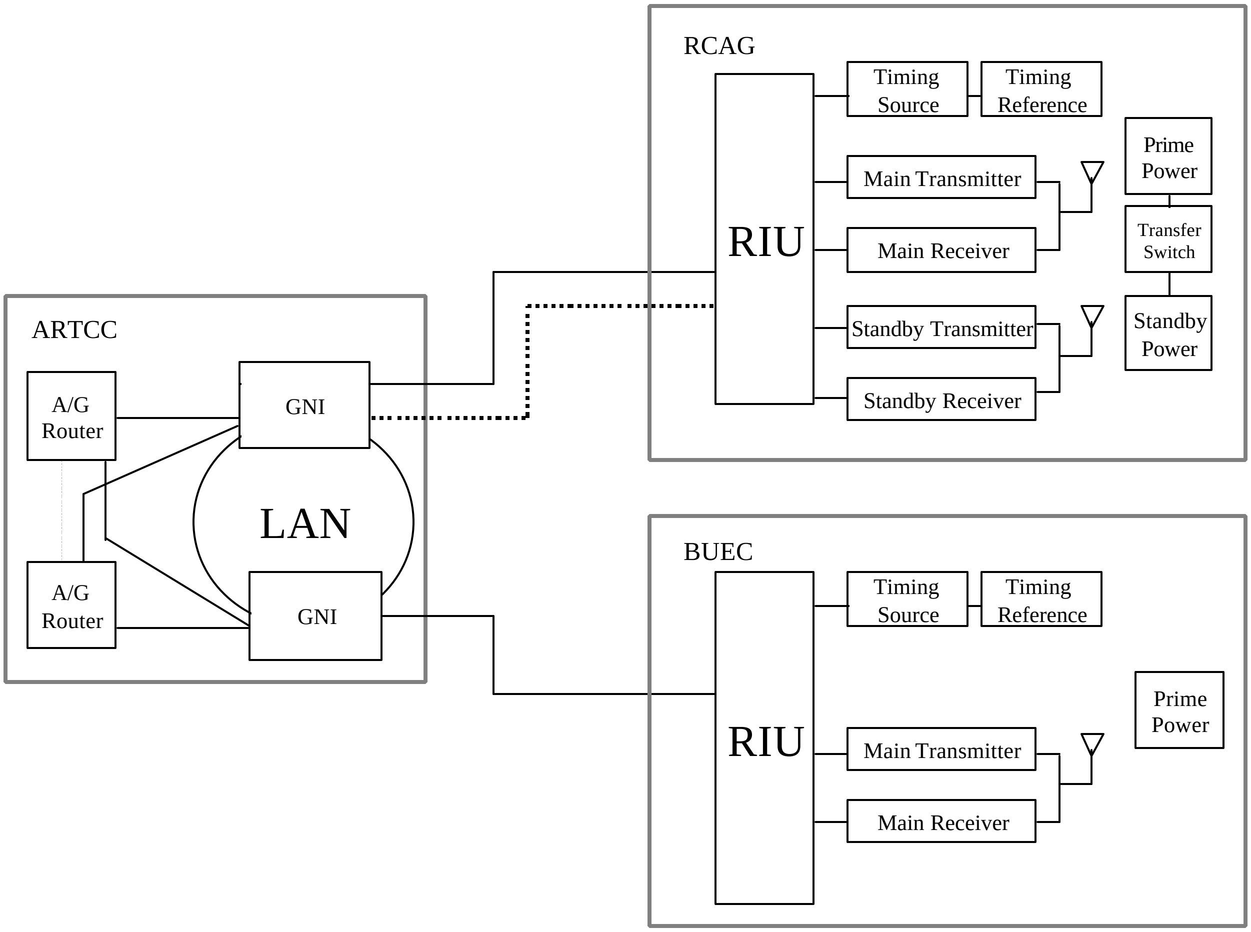


(a) Physical Configuration

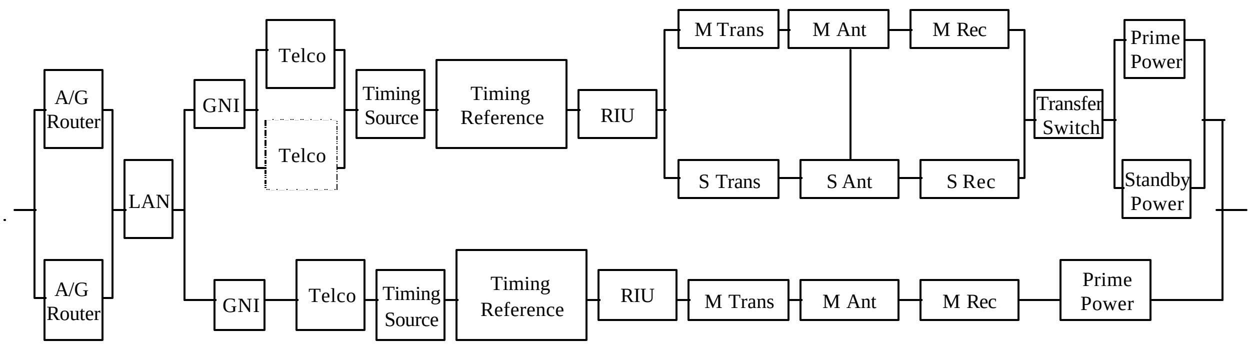


(b) Reliability Block Diagram

Figure E-8. NEXCOM En Route Data System – Non-Redundant A/G Router



(a) Physical Configuration



(b) Reliability Block Diagram

Figure E-9. En Route Data System – Redundant A/G Router

Table E-11a. Data System Availability in En Route Domain (Non-Redundant LAN)

	En Route A/G Data Service Availability* (Non-Redundant LAN)	
GNI MTBF (hrs)	Non-Redundant A/G Router A/B	Redundant A/G Router A/B
10,000	0.999883012/0.999888881	0.999983001/0.99998887
27,000	0.999883233/0.999889071	0.999983221/0.99998906
30,000	0.999883246/0.999889082	0.999983234/0.999989071
40,000	0.999883275/0.999889107	0.999983264/0.999989096
100,000	0.999883327/0.999889152	0.999983316/0.99998914

A = Single communications path
B = Redundant communications path
*Computed with non-redundant RIU and RIU MTBF of 40,000 hrs, LAN MTBF of 50,000 hrs.

Table E-11b. Data System Availability in En Route Domain (Redundant LAN)

	En Route A/G Data Service Availability* (Redundant LAN)	
GNI MTBF (hrs)	Non-Redundant A/G Router A/B	Redundant A/G Router A/B
10,000	0.999893011/0.99989888	0.999993000/0.99999887
27,000	0.999893232/ 0.99989907	0.999993221/ 0.999999059
30,000	0.999893245/ 0.999899081	0.999993234/ 0.999999071
40,000	0.999893274/ 0.999899106	0.999993263/ 0.999999096
100,000	0.999893326/ 0.99989915	0.999993316/ 0.99999914

A = Single communications path
B = Redundant communications path
*Computed with non-redundant RIU and RIU MTBF of 40,000 hrs, LAN MTBF of 50,000 hrs.

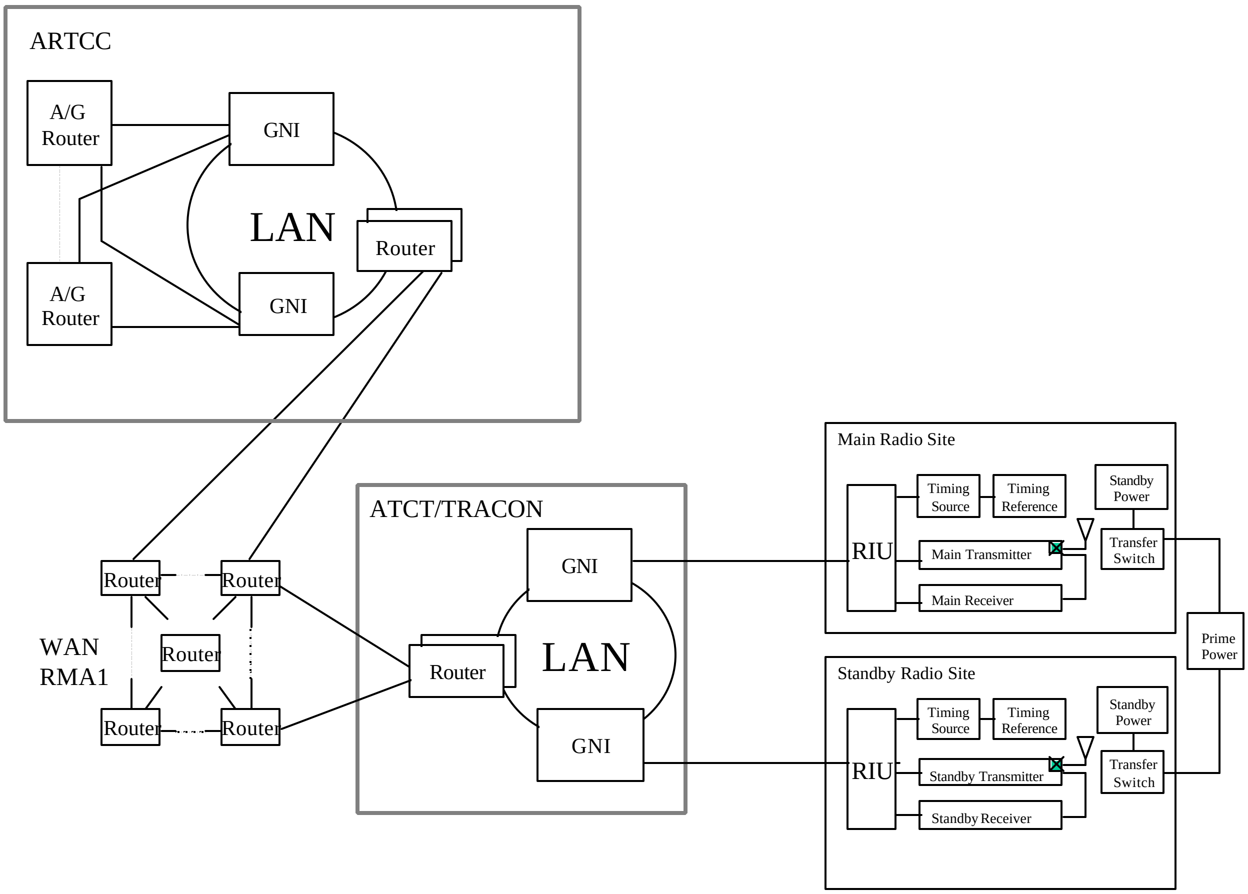
E.5.2 Terminal Data System

Figures E-10 and E-11 show two slightly different configurations for terminal data service. In Figure E-10, the assumption is that a high availability connectivity through a wide-area network (WAN) is available to interconnect the ATCT/TRACON and the ARTCC. For this case, the predicted FTI availability of 0.9999971 for RMA1 service is used. In Figure E-11, it is assumed that the WAN can provide at most an availability of 0.9979452, which is the predicted availability under FTI for RMA4 service. The 0.9999971 and the 0.9979452 should include the availabilities of the ground/ground routers.

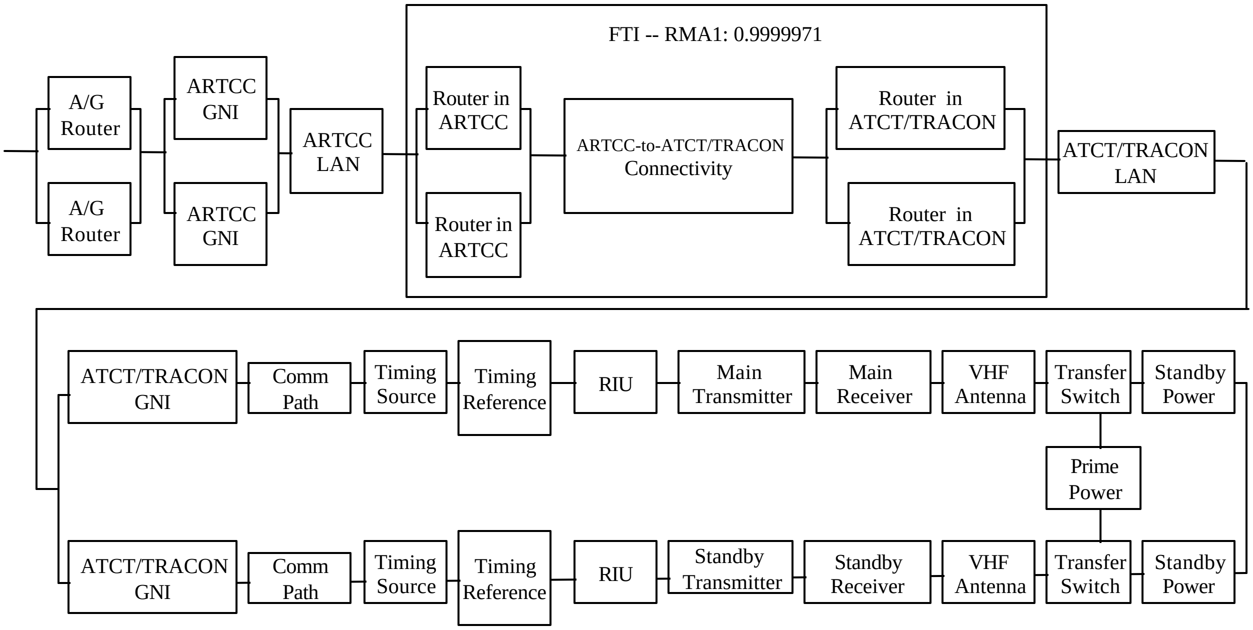
In addition, the assumption for terminal data service is that, in addition to the LAN and GNI in the ATCT/TRACON being operational, the GNI, A/G Router, and LAN at the ARTCC must be operational in order that terminal data service be operational. Redundancy of the A/G Router in the ARTCC is assumed in the data system availability computation.

Table E-12a shows that even with a high WAN availability (i.e., RMA1), terminal data service cannot achieve an availability of 0.99999 with a non-redundant LAN. If both LANs (at the ARTCC and ATCT/TRACON) are made redundant, then a 0.99999 availability can be achieved for the A/G Terminal Data System (and hence for A/G Terminal Data Service) as Table E-12b shows.

With an RMA4 WAN availability, then the terminal data service availability falls below 0.999, regardless of LAN and A/G Router redundancy.

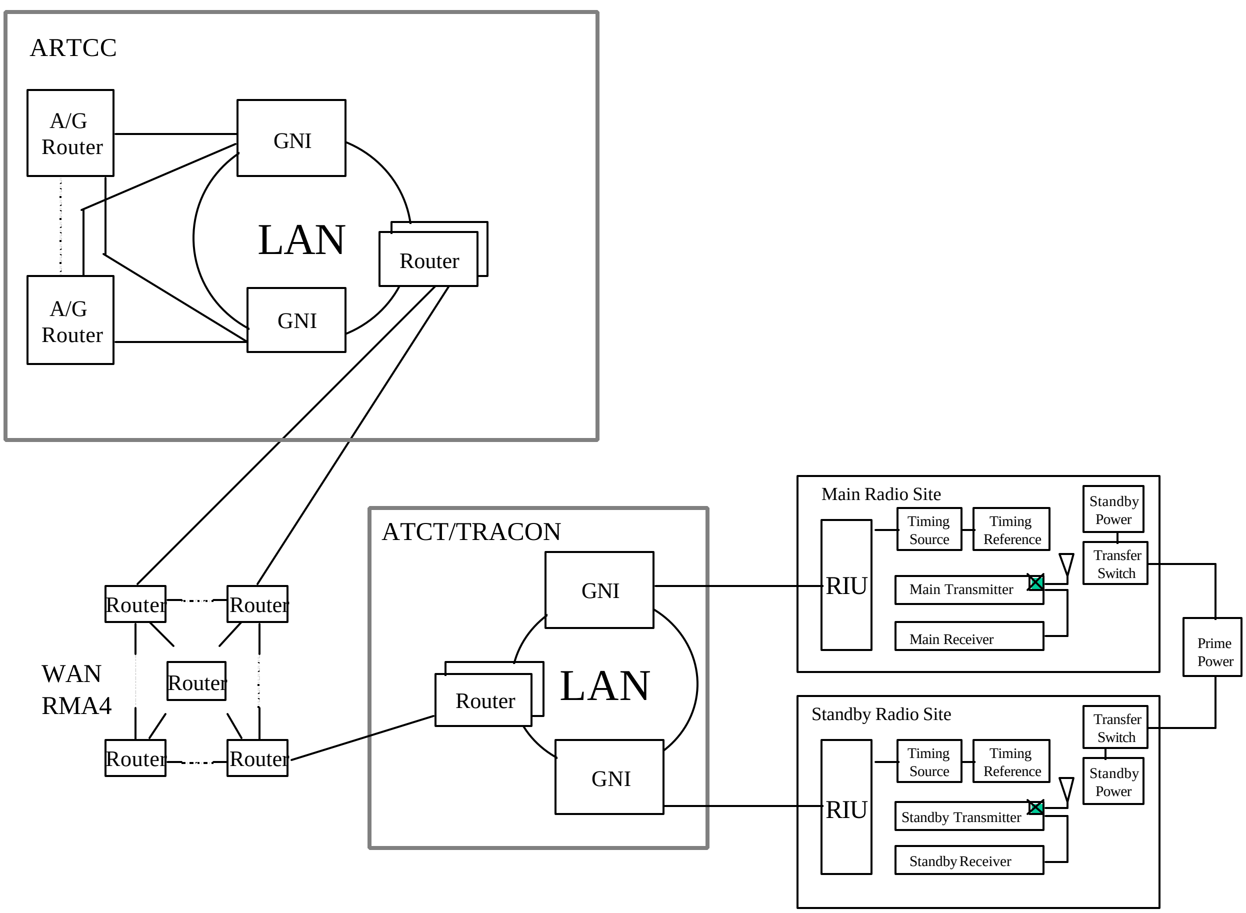


(a) Physical Configuration

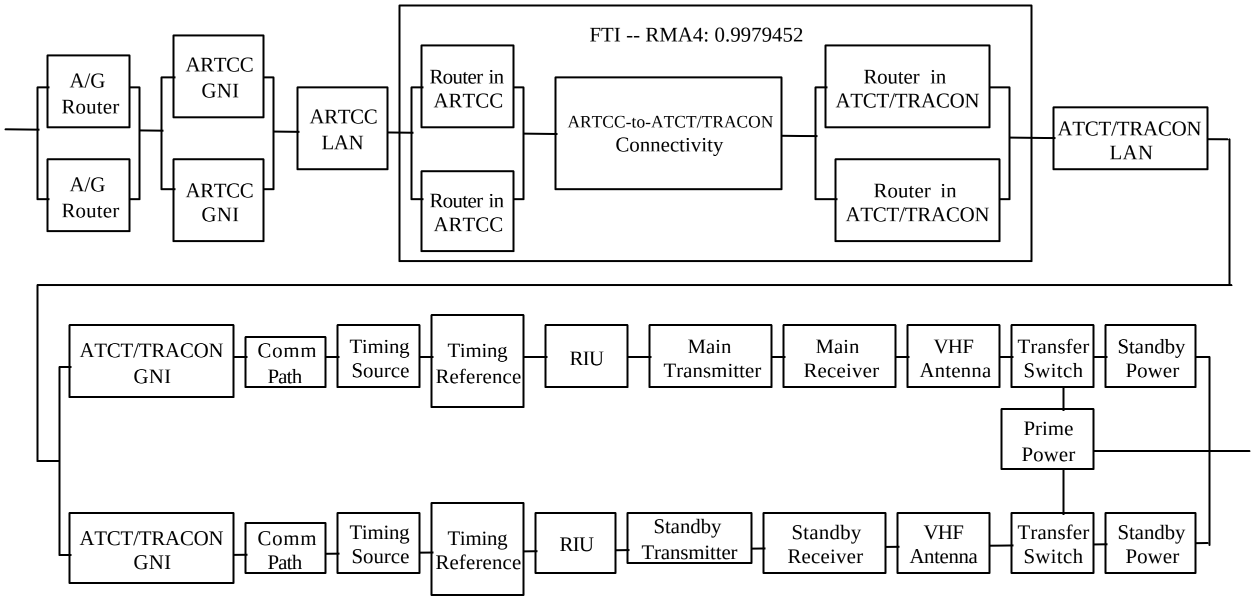


(b) Reliability Block Diagram

Figure E-10. Terminal Domain Data System -- RMA1 WAN Access to ATCT/TRACON



(a) Physical Configuration



(b) Reliability Block Diagram

Figure E-11. Terminal Domain Data System – RMA4 WAN Access to ATCT/TRACON

Table E-12a. Data Service Availability in Terminal Domain - Split M/S Configuration Non-Redundant ARTCC and ATCT/TRACON LANs

GNI MTBF (hrs)	Terminal A/G Data Service Availability*	
	RMA1 WAN	RMA4 WAN
10,000	0.999973746	0.997921894
27,000	0.999973864	0.997922012
30,000	0.999973871	0.997922018
40,000	0.999973886	0.997922034
100,000	0.999973913	0.99792206

*Computed with Redundant A/G Router and RIU MTBF of 40,000 hrs

Table E-12b. Data Service Availability in Terminal Domain - Split M/S Configuration Redundant ARTCC and ATCT/TRACON LANs

	Terminal A/G Data Service Availability*	
GNI MTBF (hrs)	**RMA1 WAN**	**RMA4 WAN**
10,000	0.999993746	0.997941853
27,000	0.999993864	0.997941970
30,000	0.999993870	0.997941977
40,000	0.999993886	0.997941992
100,000	0.999993912	0.997942019

*Computed with Redundant A/G Router and RIU MTBF of 40,000 hrs

E.6 GNI MTBF

As the previous results show, it is possible to satisfy the en route and terminal service availability requirements with a GNI MTBF of 10,000 hrs, assuming GNI redundancy of the type described earlier in this appendix. (It was not possible to satisfy the service availability requirement only for the two-sited STR configuration in the terminal environment even for a GNI MTBF of 100,000 hrs.) However, the MTBF of the GNI must be balanced against the resulting number of corrective or unscheduled maintenance actions. The curve in Figure E-12 looks into the future where NEXCOM has been extended well into the terminal environment so that there are a total of 400 facilities NAS-wide. Two GNIs are assumed per facility to account for redundancy of the type discussed earlier. In this case, quite a difference can be seen between the number of corrective maintenance actions required per year with a GNI MTBF of 10,000 hrs -- 700 -- and the number required with a GNI MTBF of 27,000 hrs -- 259. Increasing the GNI MTBF from 10,000 hrs to 27,000 hrs decreases the number of maintenance actions by 441 per year. A further increase in the GNI MTBF from 27,000 hrs to 40,000 hrs decreases the number of maintenance actions by another 84 per year. These differences could be greatly increased if the number of GNIs per facility increases and/or if the number of facilities which contain a GNI increases. Of course, the increased cost for a higher availability GNI must be balanced against the resulting decreased cost corresponding to the reduced number of maintenance actions per year.

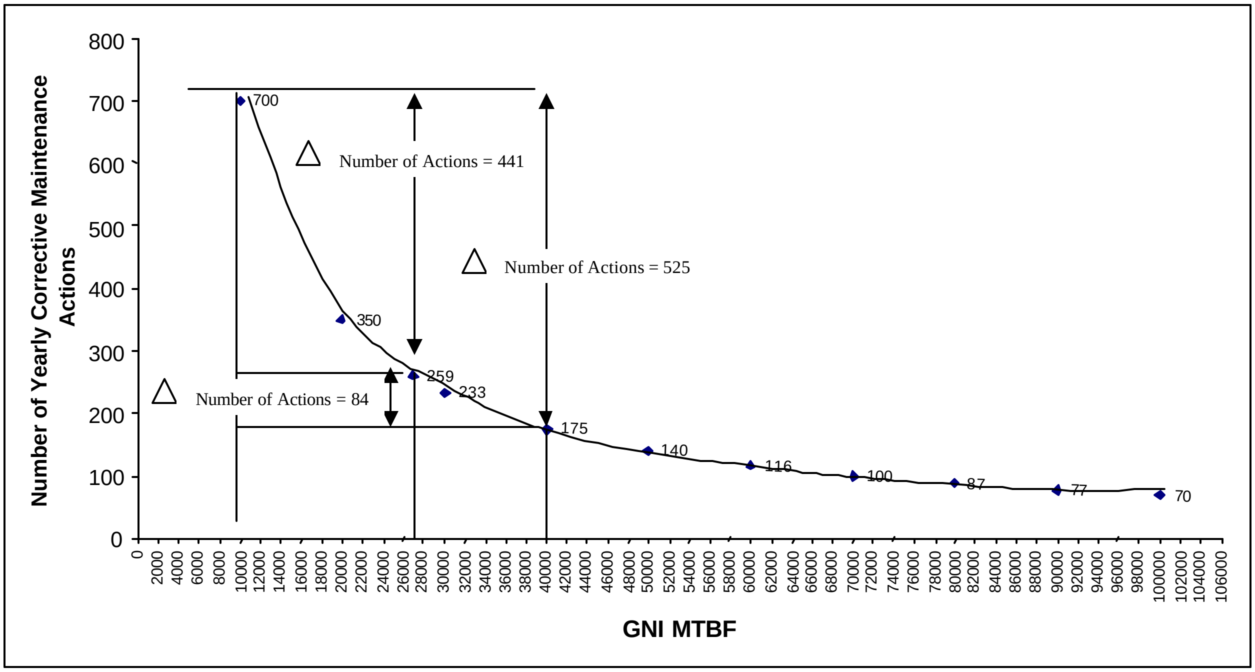


Figure E-12. Corrective Maintenance Actions per Year

E.7 Conclusions

The RD requirements for RCAG MTBO and inherent availability can be met with a T/R MTBF of 26,280 hrs and a non-redundant RIU with an MTBF of at least 27,000 hrs.

Service availability requirements can also be met in most cases with RIU of 27,000 hrs and GNI MTBF of 10,000 hrs. Redundancy is not required for the RIU, but it is required for the GNI.

Although 27,000 hrs and 10,000 hrs may suffice for the RIU and GNI, respectively, a higher MTBF is recommended to add some margin, and to reduce the number of corrective maintenance actions.

For those cases where BUEC cannot be provided, and there is only coverage from an RCAG, adding a redundant and diverse telecommunications link between the ARTCC and the RCAG can significantly increase the availability of service from the RCAG. Adding redundancy to the RIU minimally increases the service availability regardless of whether or not redundancy is added to the telecommunications link. Because there is no BUEC, a 0.99999 service availability can never be met.

When BUEC is provided, the En Route Service availability requirement of 0.99999 can only be met with GNI redundancy. Redundancy is not required for the RIU in order to meet the service availability requirement. Redundancy is not required for the ARTCC-to-RCAG telecommunications link in order to meet the service availability requirement.

In the terminal environment, VSBP, which is provided at most level 3 ATCT/TRACONs and above, is required in order to achieve a Terminal A/G Voice Service availability of 0.99999 in the M/S configuration.

It is not possible to achieve a Terminal A/G Voice Service availability of 0.99999 for the two-sited STR configuration, even with VSBP.

In order that the En Route A/G Data Service achieve an availability of 0.99999, redundancy must be added to the A/G Router and the HID/NAS.

With an RMA4 WAN (i.e., 0.9979452), it is not possible for the Terminal A/G Data Service to meet an availability of 0.99999.

With an RMA1 WAN (i.e., 0.9999971) and using the split M.S configuration, in order that the Terminal A/G Data Service achieve an availability of 0.99999, redundancy must be added to the A/G Router, the HID/NAS LAN, and the LAN in the ATCT/TRACON.

It is not possible for the Terminal A/G Data Service to achieve an availability of 0.99999 for the two-sited STR configuration even with an RMA1 WAN and redundancy added to the A/G Router and LANs.

Besides system availability considerations, redundancies of the GNI, the A/G Router, and the LANs are required if they are part of a critical service. This follows from FAA Diversity Order 6000.36 [3] which states that there should be no common points of failure for a critical service. But more than this, the GNI and A/G Router are common equipment for multiple critical voice and data connections from A/G radio sites to the voice switch and data service equipment, respectively. Without redundancy, a failure in any of these components could cause the loss of all A/G voice and data service to an ARTCC and/or ATCT TRACON.

While there is considerable latitude with respect to selecting MTBFs for the various components in order to meet a 0.99999 system availability, the implications with regard to the number of corrective maintenance actions should be considered.

E.8 References

1. Reliability Analysis Center (RAC), Rome Laboratory, Reliability Toolkit: Commercial Practices Edition, p. 404.

2. National Airspace System Performance Analysis System (NASPAS) data for FY98 obtained from Frank DeMarco, AOP-200.

3. FAA Diversity Order 6000.36

4. National Airspace System Performance Analysis system (NASPAS) data for FY98, FY99, FY00 obtained from Frank DeMarco, AOP-200.

5. National Airspace System - System Specifications - 1000 (NAS-SS-1000) document, NAS-SS-1000.

6. National Airspace System, System Requirements - 1000 (NAS-SR-1000) document, NAS-SR-1000.

APPENDIX F NEXCOM End-to-End Audio Delay Estimates

This appendix discusses the delay allocations for the NEXCOM System alternatives to assist in defining requirements for box-level specifications as well as to help make decisions for architectural alternatives and transitions.

F.1 Architectural Alternatives

The appendix will discuss two architectural alternatives, one with RIU vocoding and the other with GNI vocoding. Both architectures utilize the MDR already specified by AND-360 and some form of RIU.

F.1.1 GNI Vocoding

The second architecture places the vocoders within the Ground Network Interface (GNI) at the control site. This allows the ground telecommunications path to take advantage of the compression of the vocoder to reduce bandwidth requirements. This will also require a vocoder in the RIU to support analog audio for the UHF radios. This architecture assumes the availability of digital transmissions between the control and remote sites via either analog or digital lines. The maximum delays columns incorporate delays deal with possibilities if associated with the use of analog lines as well as other possible implementation options.

F.2 Delay Budgets

Delay budgets are being updated to reflect field measurements of operational equipment as well as based on a closer look at the MITRE prototype operation, where it was realized that certain functions were being double counted in previous budgets. Delay numbers for the Voice Switch and RCE are based on measurements conducted on fielded Voice Switching and Control System (VSCS) and RCE equipment by AND-360 and ACT-330 with the support of AS&T and CIE. Delay specifics of the VDL Mode 3 are based on the MITRE prototype system are provided by Carl Pearson of MITRE. This is making the assumption that vendors can provide similar performance in an operational system, but due to the critical nature of end-to-end delay it is felt by the author to be necessary.

The Voice Switch equipment and RCE have differing delays for the Push-to-Talk (PTT) signal than for the audio information. As such, this needs to be taken into consideration for a start-up delay, which will be greater than the steady-state audio throughput delay. Using the lower throughput numbers requires the vocoder to be always running and then the PTT signal is used to determine whether the RIU should forward the voice information for transmission. This allows the vocoder to be operating on voice even if the PTT signal has not quite arrived yet. This assumes that the clipping introduced by this difference (which is in today's operational system) is still acceptable and NEXCOM is not forced to buffer out the clipping. If so, then the start-up delay becomes the throughput delay.

The delay budgets are broken out separately for uplink and downlink due to this PTT impact, and the fact that different architectures in the air and ground system can vary the numbers.

F.2.1 Uplink Delays

The following table spells out the uplink delay allocations for the local vocoding architecture:

VDL3 Audio Throughput Delay				
	Likely	**Min**	**Max**	
Voice switch delay	1.20 ms	1.20 ms	2.00 ms	(Measured from field - VSCS)
Vocoder Analysis	60.00 ms	60.00 ms	60.00 ms	(dependent on vocoder frame size)
Processing delay	4.00 ms	2.00 ms	4.00 ms	
Clock out of vocoder	2.60 ms	1.25 ms	20.00 ms	(4/8bit Parallel @ 9600Hz / Serial @ 4800Hz)
TDMA Framing delay	84.76 ms	84.76 ms	84.76 ms	(4 frame pipeline + prep for transmission)
Modem Processing delay	5.00 ms	5.00 ms	20.00 ms	
Modem Transfer delay	1.71 ms	0.06 ms	10.00 ms	(56k/T1-1.544M/9.6k)
	158.08 ms	153.07 ms	198.76 ms	GNI Tx
Maximum LINCS delay	14.00 ms	5.00 ms	25.00 ms	(MAX 50 ms spec'd - 18.88 ms max likely)
	173.28 ms	159.27 ms	225.76 ms	Ground System (VSCE + GNI)
Processing delay	4.00 ms	2.00 ms	4.00 ms	
RIU/MDR Line Blockage	2.45 ms	0.00 ms	2.45 ms	No blockage vs. Max size packet just started
Transfer delay	0.86 ms	0.86 ms	2.73 ms	(1 vocoder frames in HDLC packet - Max 6 frames)
	7.30 ms	2.86 ms	9.18 ms	RIU Tx
Processing delay	6.00 ms	3.00 ms	6.00 ms	
	6.00 ms	3.00 ms	6.00 ms	MDR Tx
Ground to Antenna	186.59 ms	165.13 ms	240.94 ms	Assumes Vocoder Always Running
Gnd to Ant. Startup	197.39 ms	175.93 ms	253.94 ms	Start of Audio delayed by PTT signal
Processing delay	6.28 ms	3.00 ms	6.28 ms	
Receive slot overhead	4.38 ms	4.38 ms	5.42 ms	(Vocoder frame tx + squelch offset + Propagation) 4Slot TS1 vs. 3Slot TS1
Clock data into vocoder	2.67 ms	1.25 ms	2.67 ms	28 symbols
Vocoder Synthesis	20.00 ms	20.00 ms	20.00 ms	(dependent on vocoder frame size)
Airborne network delay	4.00 ms	2.00 ms	4.00 ms	(COMPLETE GUESS)
	37.32 ms	30.63 ms	38.37 ms	Aircraft Rx
Total	223.91 ms	195.76 ms	279.31 ms	[GOAL: <=250 ms]
StartUp Delay	234.71 ms	206.56 ms	292.31 ms	(Audio delayed by PTT signal)
VDL3 PTT Delay				
	Likely	**Min**	**Max**	
Voice switch PTT delay	12.00 ms	12.00 ms	15.00 ms	(VSCS maximum delay allowed)
Clipping Possible	10.80 ms	10.80 ms	13.00 ms	

The case with the vocoder in the GNI easily meets the delay requirements for the minimum and likely cases. The worst-case conditions exceed the 250 ms requirement only slightly.

F.2.2 Downlink Delays

The following table spells out the downlink delay allocations for the local vocoding architecture:

VDL3 Audio Throughput Delay				
	Likely	Min	Max	
Airborne network delay	4.00 ms	2.00 ms	4.00 ms	(estimated)
Vocoder Analysis	60.00 ms	60.00 ms	60.00 ms	(dependent on vocoder frame size)
Clock out of vocoder	2.60 ms	1.25 ms	20.00 ms	(4/8bit Parallel @ 9600Hz / Serial @ 4800Hz)
TDMA Framing delay	84.76 ms	84.76 ms	84.76 ms	Just-in-time processing for Vocoder frames 5&6
Processing delay	4.00 ms	2.00 ms	4.00 ms	
	155.37 ms	150.01 ms	172.76 ms	Aircraft Tx
Receive slot overhead	10.19 ms	5.62 ms	13.14 ms	(Vocoder frame tx + squelch offset. Includes Propagation) 4Slot TS2 vs. 4Slot TS1 vs. 3Slot TS2
Processing delay	6.00 ms	5.30 ms	6.00 ms	
RIU/MDR Line Blockage	2.45 ms	0.00 ms	2.45 ms	No blockage vs. Max size packet just started
Transfer delay	0.86 ms	0.86 ms	2.73 ms	(1 vocoder frames in HDLC packet)
	19.50 ms	11.77 ms	24.32 ms	MDR Rx
Processing delay	6.28 ms	3.00 ms	6.28 ms	
	6.28 ms	3.00 ms	6.28 ms	RIU Rx
Maximum LINCS delay	14.00 ms	5.00 ms	25.00 ms	(MAX 50 ms spec'd - 18.88 ms max likely)
Modem Processing delay	5.00 ms	5.00 ms	20.00 ms	
Modem Transfer delay	1.71 ms	0.06 ms	10.00 ms	(56k/T1-1.544M/9.6k)
Vocoder Synthesis	20.00 ms	20.00 ms	20.00 ms	(dependent on vocoder frame size)
Clock data into vocoder	2.67 ms	1.25 ms	2.67 ms	28 symbols
GNI Processing delay	4.00 ms	2.00 ms	4.00 ms	
	33.38 ms	28.31 ms	56.67 ms	GNI Rx
Voice switch delay	1.20 ms	1.20 ms	2.00 ms	(VSCS maximum delay allowed)
	48.58 ms	34.51 ms	83.67 ms	Ground System
Total	229.72 ms	199.30 ms	287.03 ms	[GOAL: <=250 ms]

With the GNI providing the vocoding function, the minimum and likely cases can easily meet the ICAO end-to-end requirements. The worst-case condition is only slightly worse than the case with the RIU providing the vocoding function. The major difference is the use of modems for analog transmission, which can add significant processing delays to the system. Care must be taken in making sure the modem does not have excessive delays.

F.2.3 PCM Voice Interface

For comparison purposes, the delay implications of using the proposed PCM voice interface between the RIU and MDR to handle uplink DSB-AM voice communications are provided below:

DSB-AM PCM Audio Throughput Delay				
	Likely	**Min**	**Max**	
Voice switch delay	1.20 ms	1.20 ms	2.00 ms	(Measured from field - VSCS)
Vocoder Analysis	60.00 ms	60.00 ms	60.00 ms	(dependent on vocoder frame size)
Processing delay	4.00 ms	2.00 ms	4.00 ms	
Clock out of vocoder	2.60 ms	1.25 ms	20.00 ms	(4/8bit Parallel @ 9600Hz / Serial @ 4800Hz)
TDMA Framing delay	84.76 ms	84.76 ms	84.76 ms	(4 frame pipeline + prep for transmission)
Modem Processing delay	5.00 ms	5.00 ms	20.00 ms	
Modem Transfer delay	1.71 ms	0.06 ms	10.00 ms	(56k/T1-1.544M/9.6k)
	158.08 ms	153.07 ms	198.76 ms	GNI Tx
Maximum LINCS delay	14.00 ms	5.00 ms	25.00 ms	(MAX 50 ms spec'd - 18.88 ms max likely)
	173.28 ms	159.27 ms	225.76 ms	Ground System (VSCE + GNI + Telco)
Processing delay	4.00 ms	2.00 ms	4.00 ms	
Clock data into vocoder	2.67 ms	1.25 ms	2.67 ms	28 symbols
Vocoder Synthesis	20.00 ms	20.00 ms	20.00 ms	(dependent on vocoder frame size)
RIU/MDR Line Blockage	10.48 ms	0.00 ms	10.48 ms	No blockage vs. Max size packet just started
Transfer delay	10.48 ms	10.48 ms	10.48 ms	(PCM voice frame in HDLC packet)
	47.63 ms	33.73 ms	47.63 ms	RIU Tx
Clock drift	0.90 ms	0.90 ms	1.80 ms	
Processing delay	6.28 ms	3.00 ms	7.20 ms	
	7.18 ms	3.90 ms	9.00 ms	MDR Tx
Ground to Antenna	228.09 ms	196.90 ms	282.39 ms	Assumes Vocoder Always Running
Gnd to Ant. Startup	238.89 ms	207.70 ms	295.39 ms	Start of Audio delayed by PTT signal
Processing delay	6.28 ms	3.00 ms	6.28 ms	
Clock into D/A	0.13 ms	0.13 ms	0.13 ms	8000Hz
Airborne network delay	4.00 ms	2.00 ms	4.00 ms	(COMPLETE GUESS)
	10.41 ms	5.13 ms	10.41 ms	Aircraft Rx
Total	238.49 ms	202.03 ms	292.79 ms	[GOAL: <=250 ms]
StartUp Delay	249.29 ms	212.83 ms	305.79 ms	(Audio delayed by PTT signal)
PCM PTT Delay				
	Likely	**Min**	**Max**	
Voice switch PTT delay	12.00 ms	12.00 ms	15.00 ms	(VSCS maximum delay allowed)
Clipping Possible	10.80 ms	10.80 ms	13.00 ms	

F.3 Example Implementation Delay Budget

F.3.1 PCM Maximum Audio Processing Delays

F.3.1.1 Uplink PCM Delay in RIU

	79.2ms	time to sample, process & transmit two 25ms PCM frames
	Toff	Timing offset (T1 propagation delay) from RIU to MDR
total:	Toff + 79.2ms	

The 79.2ms delay can be expressed as: [4.2ms + (N+1)*Tvf],
Where, N=2, and Tvf is 25ms frame size. (from ICD Appendix. C.5.2.e)

Note: The maximum uplink PCM delay in the RIU is the time from PTT to when the second 25ms PCM frame has been sent to the MDR. The MDR will not begin modulation until up to 9ms after the 2nd PCM frame has been received from the RIU.

F.3.1.2 Downlink PCM Delay in RIU

	9ms	RIU processing time
total:	9ms	

Note 1: The above delay is relative to the receipt of the 2nd PCM voice message received from an MDR receiver at the start of a voice reception.

F.3.1.3 Uplink PCM Delay in MDR

	9ms	MDR processing time
total:	9ms	

Note 1: The above delay is relative to the receipt of the 2nd PCM voice message received from a RIU at the start of a voice transmission.

F.3.1.4 Downlink PCM Delay in MDR

	10ms	squelch break
	82.5ms	time to demodulate, process & send two 25ms PCM frames to RIU
	Toff	Timing offset (T1 propagation delay) from MDR to RIU
total:	Toff + 92.5ms	

The 82.5ms delay can be expressed as: [7.5ms + (N+1)*Tvf],
Where, N=2, and Tvf is 25ms frame size. (from SSS, section 3.2.2.1.1.2.1.e)

Note: The maximum downlink PCM delay in the MDR is the time from squelch break to when the second 25ms PCM frame has been sent to the RIU. The RIU will not begin audio output until up to 9ms after the 2nd PCM frame has been received from the MDR.

F.3.2 VDL Mode 3 Maximum Audio Processing Delays (local RCE vocoding)

F.3.2.1 Uplink VDL Mode 3 Delay in RIU

	60ms	vocoder encoding delay
	94ms	maximum 5 vocoder frames (100ms) silence padding. *Note 1: Frame 1 of silence pattern completes modulation 6ms earlier than the end of Frame 6 T1 transmission to the MDR.*
	6ms	RIU processing time (2.6ms RIU/MDR T1 line blocking overlaps this interval)
	1 ms	Send 6th vocoder frame's voice burst message over T1 (27 bytes) single vocoder frame.
	Toff	Timing offset (T1 path delay) from RIU to MDR
total:	Toff + 161ms	

Note: It is assumed above that the vocoder encoder frame timing is aligned with VDL Mode 3 MAC timing for minimal delay. Since you don't know when a PTT will occur, you must continuously encode the input audio, even when PTT is inactive**,** to avoid losing any audio ("clipping"). Regardless of where a PTT occurs within a 20ms vocoder frame boundary you get the same 60ms encoding delay relative to PTT going active. Figure F-1 shows the RIU/MDR uplink timing. Also, note that the 2.6ms T1 line blocking on the RIU/MDR Link overlaps the 6ms RIU processing time interval and does not add directly to the audio delay. It is presumed that once the RIU is aware of the PTT signal, it will not allow another non-voice message to "Block" voice messages until PTT goes inactive.

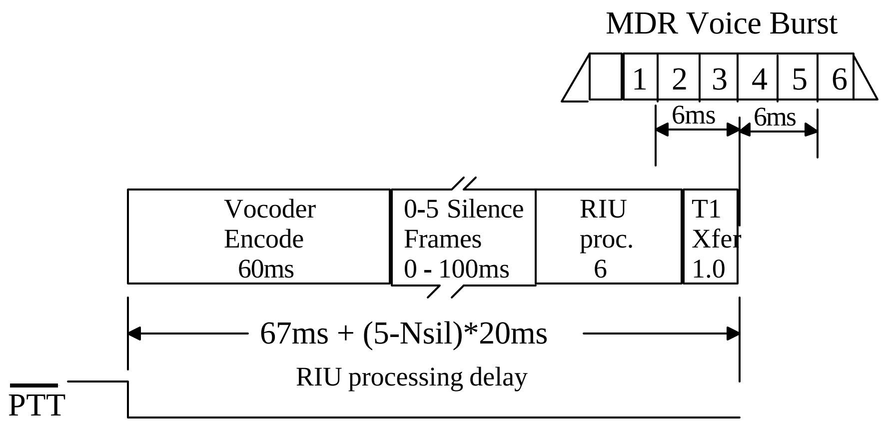
If you alternatively aligned vocoder encoder frame boundaries to begin on PTT going active, you would incur 0-20ms additional delay. (Example: Suppose you get a PTT and immediately start encoding a 20ms vocoder frame. 60ms later you have the first encoded audio frame but it may be too late to format & send the frame for an upcoming time slot (to make message arrival time deadlines in the MDR). This would result in 0-20ms of additional voice delay. This re-emphasizes the requirement to run the vocoder encoders continuously & synchronize the frame timing to minimize voice delay.

If vocoding in the GNI, the RIU delay is:

$$0.006 + \frac{(9 * N + 11)}{20{,}000}\,\text{sec}\,,$$

where N = number of vocoder frames in voice burst message and the RIU processing time is 6ms. The equation above accounts for maximum HDLC bit stuffing delay. The basic voice burst message is 15 bytes overhead + 12 bytes per vocoder frame + bit stuffing which is applied to all bytes except for the HDLC start/end flags.

Any RIU-MDR non-voice message transmission (2.6ms) that began prior to the reception of the voice message from the GNI would overlap the 6ms-processing interval & not add to the RIU delay.



Nsil = no. silence frames inserted at RIU (0-5)

Uplink audio delay (not including airborne decode time) = 67ms + (5-Nsil)*20ms + Nsil*20ms - 6ms = 161ms

Figure F-1 RIU/MDR Uplink VDL Mode 3 Voice Timing (vocoder frame 6)

F.3.2.2 Downlink VDL Mode 3 Delay in RIU (vocoding in the RIU)

The following delays are relative to the Time of Arrival (TOA) in the 1st voice burst message of a reception from a MDR receiver:

	5.28ms	(55.5 symbols from TOA to end of vocoder frame 1)
	8.00ms	MDR max. processing time
	4.00ms	T1 transfer (1 frame), T1 line blockage, clock oscillator drift
	Toff	One-Way Timing offset on RIU/MDR link (T1 path delay)
	6.00ms	RIU max. processing time
	20.0ms	Vocoder decode time
total:	Toff + 43.28ms	

Notes:
The above assumes the vocoder decoder frame timing is asynchronous and can vary from reception to reception depending on the air-ground propagation delay, which can vary from 0 to 8.3ms (max 3-slot TS2 squelch window) for different aircraft. If a voice reception from an aircraft at 0 range occurs on the same time slot immediately following (120ms after) the end of a voice reception from an aircraft at maximum range, the RIU must allow the previous vocoder (final frame) playback to complete causing the 2nd aircraft to incur the same propagation related voice delay as the first aircraft for the duration of that reception from the 2nd aircraft.
If there is at least one 120ms TDMA frame with no voice following the end of the first voice reception, then the voice message from the second aircraft incurs no additional delay.

The less desirable alternative to this approach would be to run the vocoder decoder synchronously with the fixed MAC slot timing, always adding the maximum propagation delay (8.3ms) +Toff +43.28ms relative to the voice Logical Burst Access Channel (LBAC) TOT (not actual TOA).

If vocoding in the GNI, the maximum RIU delay relative to the reception of the voice message from the MDR is:

$$0.0119 + \frac{(9 * N + 11)}{4{,}375}\,\text{sec},$$

where, N = number of vocoder frames in the voice burst message and the RIU/GNI T1 line blocking is 11.9ms. The 2nd term in this equation is the time to transmit the message over the T1 link, including maximum HDLC bit stuffing.

Note: The 6 ms RIU processing time runs concurrent with the 11.9ms line blocking interval and need not be added to the total delay.

F.3.2.3 Uplink VDL Mode 3 Delay in MDR

	6ms from receipt of vocoder frame 6 to start of modulation of frame 6
total:	6ms (SSS 3.2.1.6.7, parameter Tm3)

Note: The MDR has 6ms to process vocoder frame 6 prior to the start of frame 6 modulation, since the RIU will be delivering the vocoder frame 6 message "just in time". The vocoder/MAC delays are *accounted for in the RIU. A MDR transmitter can't add arbitrary delay to a voice transmission, since by definition it has to transmit at a time specified by the TOT field contained in the RIU voice burst message.*

F.3.2.4 Downlink VDL Mode 3 Delay in MDR

	8ms	demod/processing of 1st vocoder frame in burst (SSS, sec.3.2.1.6.6b, parm Tmp)
	4ms	includes time to send single frame voice burst message + T1 line blocking + 450us clock drift error
	Toff	Timing offset (T1 path delay) from MDR to RIU
total:	Toff + 12ms	

Note: This delay could be significantly smaller, depending on how efficient the MDR is. e.g., MDR demod/processing may only take 2-3 ms and MDR could ensure line blocking did not add to the delay (the 2.6ms line blocking would be concurrent with MDR demod/processing delay). So, an efficient MDR could result in delay as small as 3.6ms.

F.3.2.5 Uplink VDL Mode 3 Delay in GNI (Figure F-2)

	60ms	vocoder encoding delay
	94ms	maximum 5 vocoder frame (100ms) silence padding. *Note 1: Fr 1 of silence pattern is modulated 6ms earlier than end of voc fr 6 T1 transmission ends if worst case timing in RIU & on T1 line.*
	6ms	GNI Processing Time
	1.5ms	GNI max. vocoder timing uncertainty
	4.6ms	Send 6th vocoder frame's voice burst message over T1 (27 bytes) single vocoder frame (assumes a single DS0 for GNI/RIU).
	Toff	Timing offset (T1 path delay) from GNI to RIU
total:	Toff + 166.1ms	

***Note:** No T1 line blocking should occur when sending vocoder frame 6 since the GNI will be aware of the PTT since before sending frames 1-5. Although some GNI/RIU T1 line blocking may occur when sending vocoder frames 1-5 to the RIU, it does not contribute to the audio delay. Vocoder frames 1-5 only need to arrive at the MDR 8.5ms prior to ramp-up/start of frame modulation. See Figure F-3 for example of message transmission timing for frames 1-6.*

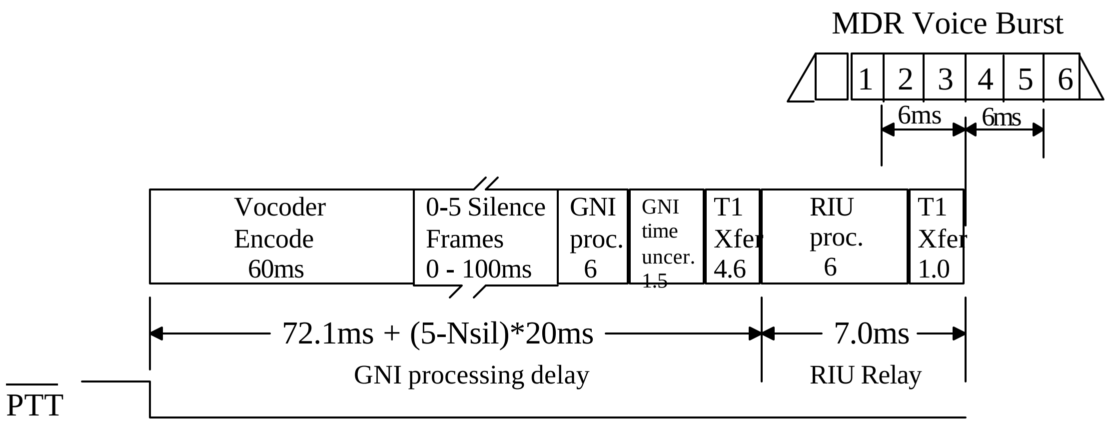
F.3.2.6 Downlink VDL Mode 3 Delay in GNI

The following delays are relative to the TOA in the 1st voice burst message of a reception from the MDR receiver (vocoder frame 1 sent by itself):

5.28ms	(55.5 symbols from TOA to end of vocoder frame 1)
8.00ms	MDR max. processing time
4.0ms	T1 transfer of frame 1 + blockage from MDR to RIU
Toff1	One way Timing offset on MDR/RIU link (T1 path delay)
16.5ms	T1 DS0 line blockage, T1 DS0 transfer (1 frame), RIU to GNI note: 6ms RIU processing is concurrent with this 16.5ms interval
1.5ms	GNI epoch timing uncertainty
Toff2	One way Timing offset on RIU/GNI link (T1 path delay)
6.00ms	GNI max. processing time
20.0ms	Vocoder decode time

total: Toff1 + Toff2 + 61.28ms

Notes:
1. *The RIU must pass along the TOA field from the MDR to the GNI.*
2. *This is also the "minimum" allowed delay in the GNI to avoid voice underflow. i.e., a GNI should adjust its delay to the above value. If the specific MDR/RIU/GNI maximum processing times are known to the GNI and they are less than the absolute maximums shown above, the GNI may reduce the delay appropriately.*

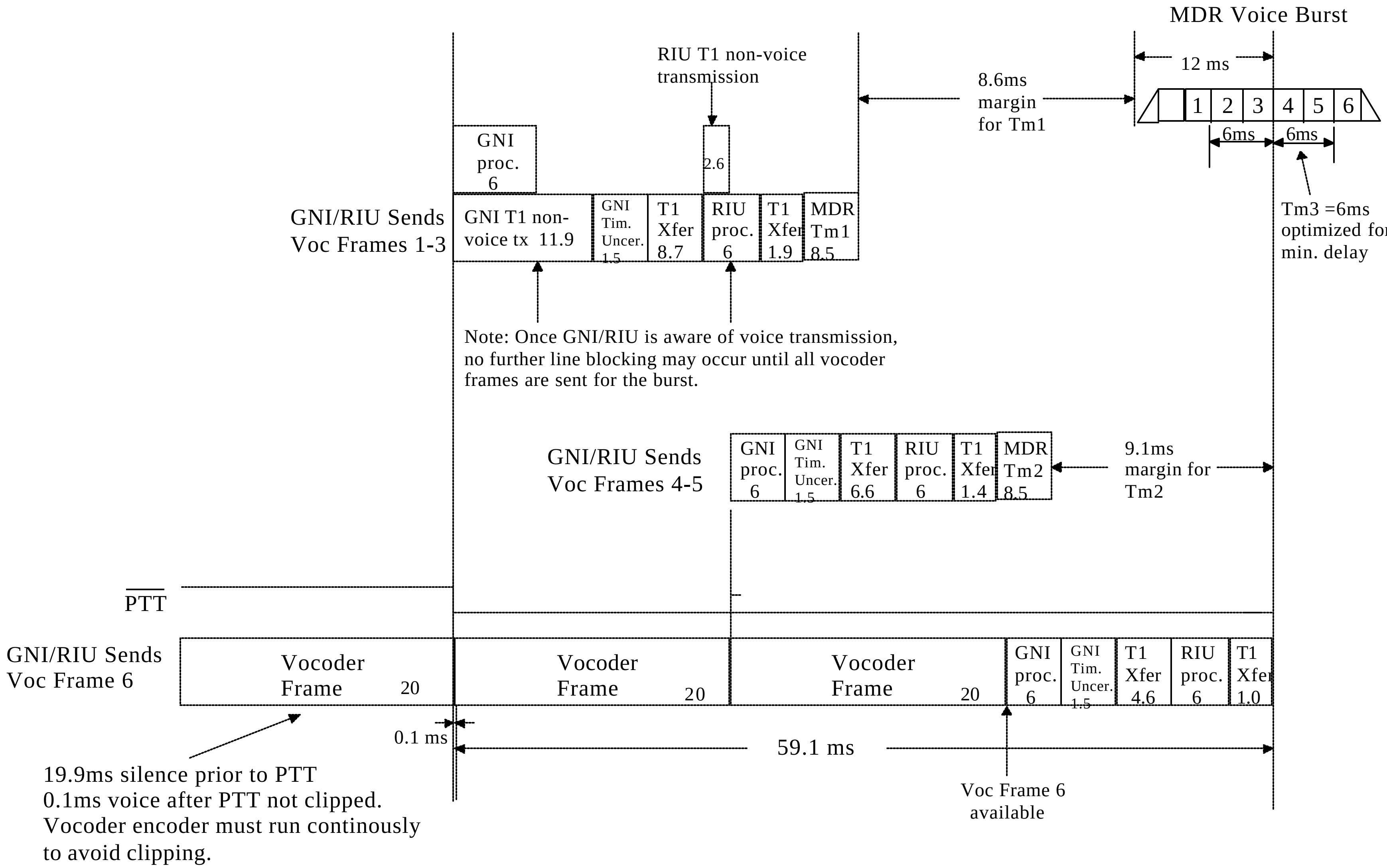


Nsil = no. silence frames inserted at GNI (0-5)

Uplink audio delay (not including airborne decode time) = 72.1ms + (5-Nsil)*20ms + Nsil*20ms + 7.0 (RIU) - 6ms = 173.1 ms

Assumes GNI/RIU Telco link uses a single DS0 (56kbps) with same HDLC message format as RIU/MDR

Figure F-2 GNI-RIU-MDR Uplink VDL Mode 3 Vocoder Timing



Uplink audio delay (not including airborne decode time) = 59.2ms + 100 (5 silence fr) + 19.9ms(voc fr silence) - 6ms (MDR fr 1 mod time) = 173.1 ms
Note: The uplink delay is the same (171.7) regardless of where PTT occurs within Vocoder frame

Assumes GNI/RIU Telco link uses a single DS0 (56kbps) with same HDLC message format as RIU/MDR

Figure F-3 GNI-RIU-MDR Uplink Vocoder Timing, frames 1-6

F.4 Conclusions

All in all, RIU vocoding will likely require waivers to the 250 ms Controller to Antenna delay requirement in many cases. The GNI vocoding option will likely only require waivers where there are long delays in the ground telecommunications segment. Furthermore, the PCM Voice interface between the RIU and MDR is not foreseen to cause any significant delay implications to the operation of the DSB-AM system.